FERTILIZERS

for GREENHOUSE and GARDEN CROPS

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By

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AUTHORS' PREFACE

THE demand for both general and specific information relative to the soils and fertilizers for garden and greenhouse crops has been insistent enough to warrant the publication of this little volume. The relatively large amount of capital invested in each square foot of greenhouse area and the cost of fuel and the labor required in maintenance made the growing of plants under glass an expensive undertaking. Strange as it may seem, the best way to make it relatively lower is to spend more on certain items of production. While the costs mentioned can be reduced sometimes, this can only be accomplished to a small extent, but production can often be increased by the judicious handling of soil fertility. Rapidity of growth, yield and quality, all of which influence profits, depend extensively on soil fertility; consequently, commercial fertilizers assume great importance in intensive horticulture. It is recognized, however, that money can be wasted and plants injured by improper use of fertilizers.

Because of variations in soils and in environmental conditions, and because of differences in the growth characteristics and nutrient requirements of plants, it is more practicable to offer suggestions regarding the use of fertilizers than it is to make specific, hard and fast recommendations. Such recommendations as are made will often have to be modified to fit individual cases.

The present work is designed to afford the grower a better understanding of his fertility problems and at the

same time to outline for him a soil management and fertilizer program that is both adequate and comparatively simple. Pursuit of this latter objective necessitates a more or less empirical treatment of certain phases of the subject. The recommendations made are based on experimental evidence and the best practices of specialists in their respective lines.

The authors hope that this book will prevent many mistakes and many useless expenditures and that it will provide a foundation for constructive study of individual problems. And may it serve as a stimulus to better quality, greater productivity and larger profits. With these aims in view, this volume is dedicated to the wide awake growers.

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CHAPTER I

THE SOIL

"IT is the Earth," wrote Pliny, some 2000 years ago, "that, like a kind mother, receives us at our birth and sustains us when born. It is this alone, of all elements around us, that is never found an enemy to man. The body of waters deluges him with rains, oppresses him with hail and drowns him with inundations; the air rushes in storms, prepares the tempest, or lights up the volcano; but the Earth, gentle and indulgent, ever subservient to the wants of man, spreads his walks with flowers and his table with plenty; returns with interest every good committed to her care, and though she produces the poison she still supplies the antidote; though constantly teased more to furnish the luxuries of man than his necessities, yet even at the last she continues her kind indulgence, and when life is over piously hides his remains in her bosom."

All plant life begins with a single cell, which is a dwelling place for that vital fluid known as protoplasm. This material possesses a strong affinity for water and by a special process draws it into itself until the cell wall is fully distended. This process is osmosis, or the attraction which a denser liquid has for one less dense. The soil water, charged with various nutrient elements, is drawn through the cell walls by the protoplasm. The nutrients thus obtained are passed from cell to cell. The protoplasm builds a new wall and a new cell in which a very vital

part—the nucleus—is included. This is known as cell division and by means of it the plant increases in size. Plant vigor depends upon the proper action of individual cells and it is desirable to know the functions of the cells for a better understanding of plant growth.

Plant cells do not function separately, but collectively, in groups. These groups are known as tissues and make up the main vegetative structures of the plants. They are commonly known as roots, stems and leaves. These structures perform special functions, some of which are very important; others less important but nevertheless necessary. The root is primarily concerned with the absorption of water and nutrients and for providing anchorage for the plant. In some cases roots contain storage tissues for elaborated foods. The stem acts as a connecting link and transportation system between the roots and leaves. It varies according to the type of plant and is very short in spinach and extremely long in chrysanthemums. The leaves manufacture foods which are used for growth and development.

A typical plant, as a chemist would view it, is composed principally of water, the percentage varying from approximately 50 in the woody parts of trees to around 90 in very succulent plants. The framework consists principally of more or less tough, woody fiberlike material. The living matter or storage materials constitute by weight a very small proportion of the plant. The framework, living material and storage materials are made largely from carbon and water, which disappear when the plant is burned, leaving a small amount of ash, the so-called inorganic material.

The carbon in the plant is taken from the air; water is ordinarily abundant, and most of the worry about feeding plants concerns supplying ingredients which form but a very small amount of its total weight. Along with the

carbon and water, which disappear when the plant is burned, goes another ingredient—nitrogen. Like carbon, this abounds in the air in gaseous form, but few plants are able to utilize this store directly, and one of the concerns of the grower of plants—from trees to pansies—is to ensure a proper supply of this element to the soil.

From the soil, then, the plant takes what it cannot get from the air. Except for nitrogen, many ingredients are found in the ash. Actually, however, not all the materials found in the ash are to be considered as plant nutrients, for the plants do not always take just what they need. Furthermore, plant ashes do not make the most desirable fertilizer for all purposes, since the process of burning acts on some of the ingredients in such a way as to make them, at least temporarily, unavailable to the plant and, commercially, the important nutrients are obtainable more cheaply in other forms.

Plants may actually starve in the presence of the very elements they require, because these elements are in a form in which the plant cannot absorb them. All the inorganic materials which enter the plant are "soaked in;" *i. e.*, they enter as liquids and are not usable in the solid form. Hence, nutrient materials may be designated as quickly available, slowly available, and sometimes as "hopelessly unavailable."

Healthy root development and subsequent growth of plants depend upon soil moisture, heat, aeration and the availability of plant nutrients in the soil. The moisture in the soil is necessary partly for the solution of the elements present and their movement to the roots. The conservation of the moisture is highly important and may be attained by the use of proper methods of drainage and cultivation. Heat is provided by the sun's rays and, in greenhouses by artificial heat, while aeration is provided by the spaces which are found between soil particles.

Root Hairs

One of the most important functions of the plant is that of absorbing materials from the soil. This work of absorbing water and mineral nutrients from the soil is confined to the roots, not all of which are capable of performing the task. The younger parts of rootlets may absorb small quantities, but the major part falls on the root hairs, which, in many cases, are extremely slender and often invisible to the naked eye.

Structure of Root Hairs

The root hair is a small, tubular-shaped body, growing out of the surface cell of the root. It is a cell with the power of carrying on the various life processes and is surrounded by a non-living wall with a very thin inside lining of living membrane. The materials which enter the plant pass through the outer wall and the membrane, then to the other root cells, and, finally, into conducting tubes which carry them to other parts of the plant. Root hairs are assumed to have selective power of absorption of certain minerals. It is difficult to explain this selectivity, but we do know that two different plants growing side by side will absorb different proportions of elements present. The fact that plants differ in their chemical composition may be evidence of their different nutrient needs.

Relation of Root Hairs to Soil Particles

Root hairs wrap themselves about and spread over soil particles and come in intimate contact with them. In this way they expose a maximum surface to the particles, from which water and mineral salts are absorbed. In well-drained soil, water occurs in thin films and in masses at the point of contact of the soil particles. By growing about the particles, the root hairs become advantageously

placed for securing the nutrients. A plant with thousands of root hairs has a large absorbing surface.

Transplanting

Plants that are distubed by transplanting usually wilt. This action may take place without any apparent injury to the roots, but a closer examination will reveal the fact that root hairs have had their connection broken with the soil particles and many of the finest have been destroyed. The plant does not resume its growth until new root hairs have been formed. Because of this fact, actively growing plants. in full leaf, are difficult to transplant. Under such conditions they demand more water than in the dormant state, but the destruction of root hairs makes it impossible to supply that demand. Excessive watering does not make up for the loss of root hairs because, even though the soil is saturated with water the roots, in the absence of root hairs, cannot absorb adequate amounts.

For ages the soil has been recognized as the source from which plants draw their sustenance. The beginnings of soil go back to the remote ages when the particles of sand, grit or clay split off from the parent rock and began their movement to the present locations, through the agency of water, wind and glacier. Many of their properties were determined during this wandering process. The mineral particles alone do not constitute the soil. Decaying animal and plant life form an important part of it. The final product is reached after vegetation has sprung up and died, leaving its remains mingled with the mineral parts. While living, the plants build up complex organic matter, but upon death these substances are disintegrated and become part of the soil medium. The process may be observed readily upon any landslide. After the topsoil has slipped, the virgin soil is exposed, upon which vege-

tation springs up gradually. This dies and, together with the process of weathering, changes the character of the soil. Later, a very different type of vegetation becomes possible.

The soil is far more than a storehouse which honors requisitions for "plant food." It is a factory in which almost countless processes involving plant nutrients are going on. Soils vary in their origin and with their treatment. They vary in their nature with the climate to which they are subjected; a soil may react differently to tropic conditions in a greenhouse than it does to the rotation of a dairy farm in Wisconsin. The complexities of influences working in soils are enormous. One ingredient in a soil, unimportant as a plant nutrient, may act on another ingredient which is important, and the action may be favorable or unfavorable to plant growth. A soil may harbor actual poisons, or it may have harmless materials present in such quantities that they become in effect poisonous.

Furthermore, the soil is the dwelling place of microscopic living things, some injurious to plants and many helpful. Some of them are virtually essential to plant life, since they work over some of the essential ingredients to forms in which they are available. But, again, these organisms have their own requirements which must be met; otherwise they do not do their work. Some must have air; hence, one of the benefits from stirring of soil and, hence, part of the stimulatory effects of sandy soils. Water is needed not only for the plants, but for the organisms which prepare their food. Soil temperatures likewise effect their activity; hence, part of the benefit from a warm soil.

The soil with which the average florist or gardener deals may be classified for simplicity, as sand, sandy loam, clay loam and clay, placed in the order of their increasing

compactness. Pure sand alone has very little value as a medium for plant growth. The small particles of quartz or other materials contain no food elements in avilable form. The various loams and clays are heavier and are composed of the mineral as well as organic elements which are useful in production of plants. The difference in root systems, as well as their individual food needs, determine the kind of soil that such plants are best adapted to.

Since soils of both the heavy and moderately heavy types are found near each other in many places, the desired effects may be approximated by the combination of the light and heavy kinds. However, it is not satisfactory to lighten heavy soil by mixing it with sand alone. This reduces the nutrients in the soil, and plants never succeed so well in it as when the desired conditions are produced by mixing a heavy and a light soil. For example, there may be in one part of the grounds a soil containing 15 to 20 per cent clay, and in another part one which contains only 5 per cent clay. By mixing the two soils in equal proportions, a good combination may be secured for the best development of the type of plants in question.

In actual practice the lightening of heavy soils may be accomplished best by the addition of lime, manure, leafmold or peat. The last three change the texture and also add the necessary organic elements which are desirable for plant development. The desirability of sod land lies in the fact that it is filled with fine, fibrous roots of grasses. As these decompose through the action of numberless friendly bacteria, they furnish the humus to the soil. The presence of this organic matter, in addition to giving soils a lighter character, gives them greater aeration, makes sandy soils more retentive of moisture, and changes color of sandy soils, which increases their power to absorb the heat of the sun's rays.

Though normal soils contain only a small percentage of organic matter, certain others have very large proportions of this material and their mineral constituents are relatively low. This class comprises muck and peat soils, the latter of which may contain in the very dry state 80 per cent or more of organic matter. Peat soils owe their origin to the fact that successive generations of native plants growing in standing water become submerged on completion of their growth and the processes of decay characteristic of normal soils do not take place. The excess of water prevents the access of air and acts as a preservative. In this manner, successive layers of plant residues are laid down year after year and the deposits may accumulate to a considerable depth. In the peat so derived, the structure of the plants to which it owes its origin is still intact and gives testimony to the incompleteness of their decomposition. Peat soils may occur in any place where native growth is prolific and where such growth becomes submerged. They occur extensively in glaciated regions, in the glacial ponds and lakes, and also in bogs and marshes and low-lying lands. Muck represents a more advanced stage of decay. It is useful for certain crops, unless it contains harmful organic acids.

The decomposition of the vegetable matter in the soil is complex. The first obvious change is the loss of green color and the turning to black. This can be observed when leaves are dug into the ground. This black substance has been termed "humus" and refers to decomposed organic matter. Further decomposition results in the breaking down of carbohydrates and proteins through the agency of various soil organisms. The proteins are broken down into amino acids, ammonium compounds and, finally, into nitrates and nitrites. The last two changes are of great immediate importance, since it is upon these compounds that plant life depends largely.

In discussing the chemical phases of soil management, it must be remembered that certain elements are essential. A chain is no stronger than its weakest link, and a plant's growth may be limited by the absence of a very small amount of one element despite abundance of all others. Phosphorus will not substitute for nitrogen in the plant's diet, nor will nitrogen, however abundant, make the plant grow if it lacks phosphorus. The fact that, in a given case, nitrogen stimulates growth need not imply that the plant does not need phosphorus; it is likely to mean that the soil contains enough phosphorus. On the other hand, a nitrogen application may fail to stimulate growth not because the plant does not need it, but because it lacks phosphorus, or it lacks potash, and cannot grow without all the ingredients it requires. In actual practice it sometimes happens that nitrogen fails to produce increased growth, and that phosphorus alone likewise fails to stimulate growth, while together they produce a desirable increase. In many cases, however, only one ingredient is absent.

After all, however, a plant can utilize only a certain amount of nutrients in a given time. Above a certain unknown point further applications fail to produce increases comparable to the initial applications, and ultimately the point is reached when they become positively injurious. Sooner or later every greenhouse man has to "burn" a few plants, in trying to see how much fertilizer they will take. The soil can become too concentrated in good plant nutrients just as it does in alkali salts. There are spots in Colorado where plants will not grow because the soil contains too much nitrate.

The object of soil treatment is twofold. It concerns texture and it concerns certain chemical substances. Manures are more valuable for their effect on texture and, therefore, on water holding capacity, aera-

tion, acivity of soil organisims, than for the actual "food" they contain. The same is true of leafmold, rotted sod, green manure crops, and of all these materials constituting "organic matter." The inorganic materials added as "commercial fertilizer" represent direct increases in the chemical ingredients which are true nutrients to the plant. A few materials may be added as correctives, such as lime, and be truly beneficial, though they have little actual nutrient value for the plant.

Preparation of the Soil

In preparing the soil for outdoor crops, Fall plowing is considered especially desirable on heavier types of soil. The physical condition of the soil is improved; the vegetable matter plowed under becomes decayed to a greater extent and is thus more available to the crop in the Spring; the work in the Spring may be started earlier; many insect and fungous pests are exposed to the destroying agencies in Winter and thus reduce trouble from this source. In the South, where little freezing takes place, loss from leaching must be considered in Fall plowing practice. Should plowing be deferred until Spring, it should be done as early as it is possible to get on the ground, without, however, working it in a wet condition. Under such conditions, it may be best to apply the organic matter just before plowing. There is less danger from leaching and, in addition, the covering retards evaporation from the soil and keeps the land much longer in unsuitable condition for plowing. In heavy sod lands and when a crop is plowed under for its humus value, Fall plowing is especially desirable. The application of manure may be at the rate of 20 loads to the acre. The application of fertilizers should be deferred until Spring, although in the case of slowly available materials, such as bonemeal and rock phosphate, it is best to apply the Fall previous.

For greenhouse benches two methods are in vogue. For small places the compost method is the most advantageous. It consists of laying a thickness of sod or soil to a depth of one foot, placing on this a layer of manure four inches deep and continuing the pile to any convenient height with such alternate layers. The size of the pile varies, although six feet is a convenient width, while the length will depend upon the facilities for handling. Two or three months after the pile has been made, it is desirable to turn it in order to mix the materials and induce quicker decay. During dry seasons this process of decomposition may be hastened by applications of water. Additional fertilizers may be used when this soil is to be wheeled to the benches.

Where large quantities of soil are needed, the compost method is not practical because of its costliness. The field method used in such cases consists of applying a coating of manure to the sod land during the Summer and plowing it under in the Fall. A green manure crop may be treated in a similar fashion. In either case, thorough harrowing should follow the plowing in order to properly mix the soil. Later, just before the ground freezes, the land should be plowed again and left in the rough. In the Spring several diskings will be found necessary for proper incorporation of the materials. The soil which is hauled out of the benches may be spread upon this same field and built up again in the manner described above.

Experience teaches the wisdom of avoiding extreme soil types (heavy clays or light sands) for most crops and, further, that some plants are better on fairly heavy, some better on fairly light soils. Experience teaches that soils containing partly decayed vegetable material (rotted sod, decomposed leafmold or animal manures), other things being equal, produce the best plant growth. Ex-

perience also teaches that in the cultivation of crops bringing comparatively high returns, under conditions where every week adds heavily to the cost of production, it is good business to force growth by insuring a proper supply of quickly available nutrients through applications of fertilizers to the soil.

Soil Analysis

The combination of materials in the soil is very complex, and it is because of the difficulty in understanding their relations that so many failures occur in the growing of plants. The average florist or gardener assumes that it is possible for the soils laboratories at the State Agricultural Experiment Stations to determine these relations exactly and the amounts of elements present. Consequently, numerous samples arrive for analysis. This practice has been discouraged because of the fact that, although it is possible to determine accurately the total amount of elements present in the soil, it is extremely difficult to tell what portions of these are available to the plant. The very fact that the elements are present does not signify that the plant can make use of them. A great many factors enter into consideration. The texture and structure of the soil, its organic matter, weather conditions, plant diseases, and many other factors have to be considered before a definite answer can be given and the sender told precisely what materials to use to better his conditions. Whereas actual analysis has often shown that there are enough materials present in the soil to last the same kind of a crop for many years, yet it may all be in such a state of combination as to be absolutely useless to the plants. For these reasons, and also because of the prohibitive cost of the work, the samples which are sent for analysis are usually given an examination to determine their desirability from the standpoint of

texture or, in other words, their humus or organic matter content. The recommendations which are made indicate applications from this standpoint only. These are usually supplemented with advice on acidity and its correction. It is evident that chemical analysis, an enumeration of the ingredients in a soil, can tell comparatively little of its potentialities. We may learn how much phosphorus is in the soil, but we may need to know how much phosphorus a Chrysanthemum plant can get from that soil between July and November—quite a different matter. Chemical analysis can suggest little as to the way in which the soil bacteria will do their work of preparing nutrients.

CHAPTER II

IMPORTANT ELEMENTS

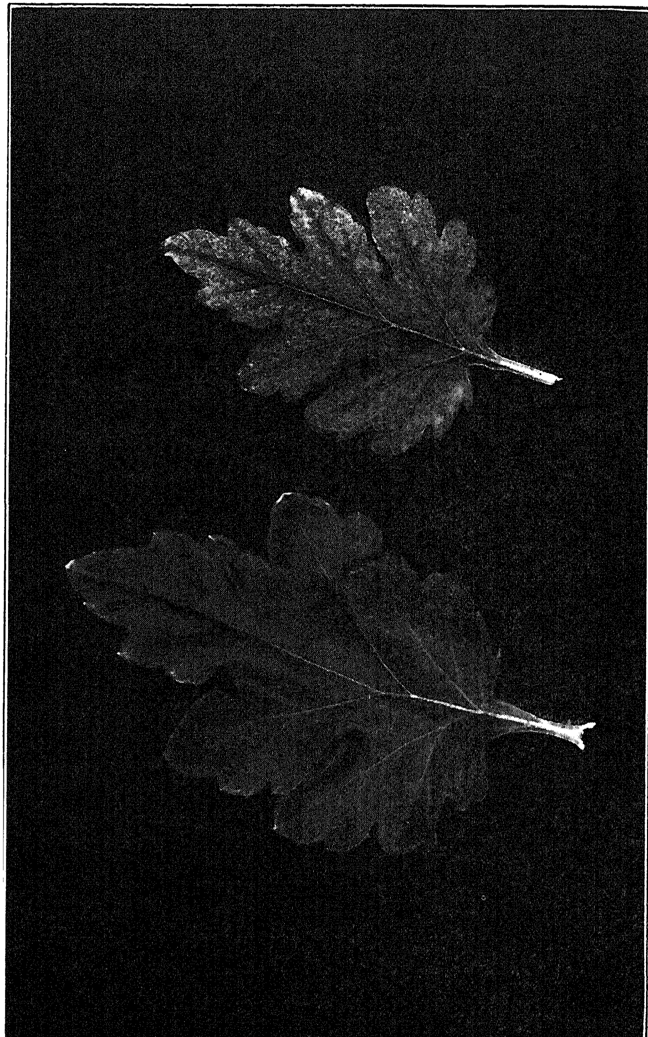
THE elements essential for plant growth may be divided into two groups: those which are secured freely from air and water, and those which are found in the soil or have to be added at certain intervals. The first group includes hydrogen, oxygen and carbon. The second is composed of nitrogen, phosphorus and potassium, which are often considered the limiting elements of plant growth; and a number of miscellaneous elements. Many of the latter have their functions in plant development and are usually found in sufficient quantities in the average soil. They are calcium, magnesium, sulphur, iron, manganese, and others.

Hydrogen, oxygen and carbon are secured without difficulty, except during droughts. Since these elements are needed in the building of plant tissue it is essential to realize where they are manufactured into plant nutrients and what is the source of energy for this purpose. The substances which are capable of building tissue are carbohydrates (sugars and starches), fats and proteins. Carbohydrates are made up of carbon, hydrogen and oxygen; fats also contain the same elements but in different proportions; and proteins possess, in addition to these, such elements as nitrogen, phosphorus, sulphur and possibly others. Only green plants have the power of manufacturing these foods out of the raw materials at hand.

The process known as photosynthesis is bringing together and building up complex substances out of the raw materials by the aid of light. The raw materials in this case are carbon dioxide from the air and water from the soil. The former enters the plant through the pores in the leaf; water enters through the root hairs. The two chemicals are brought together in the cells which contain the green coloring matter, or chlorophyll, which is confined to specialized living bodies in the cells. Through the energy of light, which is absorbed by the green coloring matter, the raw products are transformed into sugars or starches. Part of the carbohydrate is used in respiration; some of it is converted into cellulose for the formation of walls of new cells and the thickening of the old; part of it is used in the making of oils and proteins.

Role of Important Elements

A clear understanding of the functions of nitrogen, phosphorus and potash is essential for the appreciation of their value and usage. The soil nutrient supply, as it affects growth, is of great importance and much of the fertilizer that is used is valuable principally because of one element—nitrogen. Most greenhouse composts, those used in the benches and solid beds, or those used for potting or in flats, contain an abundance of the other elements. Indeed, analysis would probably show that the soil of a bench that has been growing Roses for four or five years, or a pot that has been growing a fern for two years, still contain all of the lime, magnesium, iron and potash that those same plants would be likely to require for several years. This is not saying that it will never be found profitable to add these materials or fertilizers containing them. It simply means that most greenhouse composts or soils contain them in relatively large quantities and that plants use them in relatively small amounts.



Normal Leaf

Lack of Nitrogen

On the other hand, the nitrogen supply of the soil often becomes deficient. Though not required by the plant in large quantities, it is subject to leaching and, perhaps in some instances, burning out. The result is that the fertilizing of greenhouse crops becomes largely a matter of manipulating their nitrogen supply. Other materials have their place in the greenhouse management of soils but are secondary to that of nitrogen.

The statements that have been made might almost lead one to infer that the more nitrogen a plant can receive the better. This is true only within certain limits. When quantities are available to the plant, greatly in excess of that which it actually requires for healthy growth, it absorbs more than it should. The result is a soft, succulent type of growth that may be described as lacking proper body or texture. Furthermore, there is always the possibility of applying nitrogenous (or other) fertilizers in such large amounts that they have a caustic or burning effect on the roots and in that way do far greater harm than good.

Diagnosing Nitrogen Supply

The grower can tell by the general appearance and manner of growth when nutritive deficiencies are responsible for unsatisfactory results. If the leaves are of good color, but are too few and too small, deficiency in the food substances manufactured from the elements of the air may be suspected. This is the natural result of lack of water, too close cutting, too much pruning or pinching, insect and disease attack or any other factor that may injure or interfere with the work of the leaves. It is most likely to develop during the short, cloudy days of Winter. On the other hand, a slowing down of growth accompanied by a distinct change in the foliage from a dark green to a light green or to a yellowish green, usually is a symptom

Lack of Phosphorus and Nitrogen

Normal Leaf

of nitrogen deficiency. The same thing is true of fruits. Other factors may cause the same symptoms, but if they do, it is usually through their influence on nutritive conditions within the plants. The yellowish tinge that the leaves assume when this is due to a nitrogen deficiency is usually unaccompanied by any noticeable dropping of the leaves. That which is occasioned by overwatering or insect or disease attack, etc., is likely to be accompanied by considerable foliage loss. Oversupply of nitrogen is manifested by extremely heavy, dark green brittle foliage, long internodes, weak stems, late flowering and susceptibility to disease and insect attack.

Nutrients Associated with Flower Formation

It is not known exactly what the internal nutritive conditions are in every case that permit or that necessitate flower bud development and flowering. Without doubt, there is considerable variation in these conditions in different plants. However, it has been fairly well established that these processes or functions proceed most freely when there has been accumulated, or is accumulating, in the plant a considerable store or surplus of the food substances that are manufactured out of the elements obtained from the air. For their accumulation to take place means that their manufacture must go on but that they are not being consumed as fast as they are being made. Stopping their use then means, temporarily at least, to stop or slow down growth, and this is often most readily done by cutting off or cutting down the nitrogen supply of the plant. It is the inadvertent or unintentional restriction or deficiency of the nitrogen supply that in a poor soil throws Sweet Peas into bloom when a foot or two high, whereas they grow to twice or three times that size before starting to bloom in a soil with a somewhat greater nitrogen supply. It is the same condition that

makes potbound Geraniums or Chrysanthemums bloom prematurely. Even Smilax or Asparagus plumosus can be made to flower and set seed by restricting its root growth and nitrogen supply and giving its tops a chance to build up a surplus of food materials made from the elements of the air. However, steadily cut off the tops of these plants, as is commonly done in the greenhouse, and they will not bloom, even with a restricted nitrogen supply, because their much reduced tops do not have enough foliage to manufacture the requisite amount of foods for the initiation of the flowering process. The same results may be brought about by the reduction of water supply.

Most plants, if left alone, will eventually develop flower buds and flower. This happens when the proper nutrient conditions develop within them and may come too soon or too late to suit the grower, who requires a product that can be sold at Christmas, or at Easter, or on Mother's Day. Consequently, control of flower bud formation and flowering to the extent of determining when these processes shall take place is necessary and desirable. The grower can do this largely through his control over the food substances which the plant makes and over the rate and extent to which it uses them week by week in the making of new growth. In brief, these effects are secured largely through his control over the nitrogen supply of the soil, although temperatures play an important part in the process. The expert flower and vegetable grower really becomes an expert user of nitrogen. This, of course, is what expert growers for generations have been, and the only new thing about this statement of the case, if indeed it is novel in any sense, is in affording a more or less scientific explanation of how good growers obtain their results. The explanation is useful in that an understanding of some of the underlying principles of plant growth

Normal Leaf

Phosphorus Deficiency

often suggests treatments or practices or the timing of operations that prevent disasters or disappointments and that make more certain the attainment of desirable results.

The good grower does not wait until marked, clean-cut symptoms of nitrogen or carbohydrate (the foods manufactured from the elements of the air) deficiencies appear before taking steps to deal with the problem. He notices the first slightest evidence of impending trouble and prevents it from becoming acute

Phosphorus

This element is necessary for all plants. In many flowering and garden plants it promotes rapid development, stimulates flower and seed production, hastens maturity, and thus gives earlier flowering and fruiting. Another quality of importance is its stimulus of root growth in heavy soils. This is extremely important, since a plant with a large root system can gather more food and water and thus resist adverse conditions to a greater degree. This increased root development may be due to greater growth of top, which is stimulated by addition of phosphorus to the soil, and which in turn induces greater root formation. The symptoms of phosphorus deficiency are characterized by normal growth but yellowing of the foliage.

Potash

A close relationship exists between this element and the formation of starches, sugars and similar compounds and their transference from one part to another. It is credited with making stems less brittle and succulent, with delaying maturity, with intensification of color, and with increasing root development. Together with other elements, it is essential in the formation of proto-

plasm, and has been found in some cases to be of help in increasing disease resistance of plants (streak of Sweet Peas, mildew on Roses). The effect of potassium compounds is more localized than of phosphates, so that potash starvation may be detected more readily. The color of the leaves becomes dull and yellowish, the stem is weaker and the plant's efficiency in making starch is lost. Such plants are the first to succumb to diseases.

CHAPTER III

FERTILIZING MATERIALS

MANURES

THE greatest influence of manure on plant growth is supplying organic matter to the soil. Its fertilizing value is secondary in character. Upon decomposition, manure produces humus which increases the absorptive capacity of the soil, acts as a binding agent in sands and produces porosity in clays. It increases the water-holding capacity of the soil, aids in the air supply, renders compounds more available, and by the addition of numerous bacteria stimulates the processes of ammonification, nitrogen fixation and nitrification. These effects are lasting and carry over from year to year.

Composition

Since the average farm manure consists of over 70 per cent liquid and 30 per cent dry matter, the percentage of plant nutrients is rather low. In general, an analysis will show 0.5 per cent nitrogen, 0.25 per cent phosphoric acid, and 0.6 per cent potash. One ton of such manure is equivalent to 30 pounds of sodium nitrate, 6 pounds of superphosphate, and 12.5 pounds of potassium chloride. In other words, 48.5 pounds of a commercial fertilizer with a ratio of 10-2-12 would equal the actual fertilizing value of a ton of barnyard manure. A fertilizer of this kind is unbalanced and for that reason its application

should be reinforced in soils that need it, by the addition of superphosphate at the rate of 50 pounds to the ton. This reinforcing material not only aids fertility, but also tends to check leaching and loss of ammonia from the soil.

DIFFERENT MANURES

The figures given above hold for an average mixed manure. Since it often becomes necessary to use manures of special types, the following analyses are given: Horse manure—0.55 per cent nitrogen, 0.30 per cent phosphoric acid and 0.40 per cent potash. Cow manure—0.40 per cent nitrogen, 0.20 per cent phosphoric acid and 0.10 per cent potash. Sheep manure—0.75 per cent nitrogen, 0.50 per cent phosphoric acid and 0.45 per cent potash. Swine manure—0.55 per cent nitrogen, 0.50 per cent phosphoric acid and 0.40 per cent potash. Hen manure—1.60 per cent nitrogen, 1.75 per cent phosphoric acid and 0.90 per cent potash. Shredded sheep manure—2.25 per cent nitrogen, 1.00 per cent phosphoric acid and 2.00 per cent potash. The figures show that sheep and hen manure are somewhat higher in their composition. They are usually sold in dried pulverized form.

Valuation

For purposes of comparison the following figures indicate the value of the nutrients contained in manures per ton when nitrogen is placed at twenty cents per pound, phosphoric acid at five cents and potash at eight cents:

Cow Manure	$3.28 per ton
Horse manure	3.94 per ton
Swine manure	3.00 per ton
Sheep manure	5.74 per ton
Sheep manure (shredded)	13.60 per ton
Hen manure	9.60 per ton

Were it not for the fact that the greatest value of manures lies outside of their actual nutrient content, commercial fertilizers would soon supersede them completely. It will be noted that the value of sheep manure is $13.60 per ton, while its actual cost in dried pulverized form is about $35.00 per ton. The process of steaming and drying has undoubtedly deprived this manure of much of its efficiency outside of actual plant materials. The grower must thus judge for himself whether their long continued use has been justified. The same holds true even in a greater measure for pulverized cow manure, which sells for approximately the same price as the sheep manure and has a fertilizing value of even smaller extent. Further, it must be realized that certain losses occur in the manures through leaching and fermentation, particularly if they are exposed to weathering. Under average conditions, the loss of nitrogen will be 40 per cent, that of phosphoric acid 30 per cent, and potash about 50 per cent. Considering these matters, the actual plant food value of manures is very small, and when we add to that the harboring of various pests in the manure, and its weed seed content, the advantages in its use are not as great as they are often deemed. From the standpoint of actual fertilizing value, this is undoubtedly true. In the greenhouses the amount of soil is comparatively insignificant, especially when we consider the amount of vegetative growth taken from it in comparison with the same area of field soil, where the total volume to a depth of two to four feet may be considered the feeding ground for roots.

Such rapid large growth in the quickest possible time means generous applications of quickly available food, and these are supplied by the various commercial fertilizers. This does not mean that manures should be eliminated in soil preparation.

OTHER FORMS OF ORGANIC MATTER

In addition to manure, other forms of organic matter are often useful in furnishing the mellowing properties needed for greenhouse and outdoor soils. Whatever the source, it is essential that the organic matter be completely decomposed so that the materials will have lost their original structure and become soft and of fine texture. Coarse, undecomposed matter is undesirable since it causes looseness of medium, resulting in excessive aeration and subsequent drying of the roots.

Leafmold

The leaves from trees and shrubs should not be burned. This material may be used in the Winter as protection for shrubs and herbaceous perennials. In the Spring it should be piled and covered with a light sprinkling of soil and kept moist throughout the season. If turned occasionally through the Summer, the material will be decayed sufficiently to permit mixing with soil for potting or other purposes. Leafmold is valuable, since it renders nitrogenous materials gradually available and protects fine roots from injury by absorbing some of the more quickly available compounds.

Peat

Comparative scarcity of manure and better knowledge of soils, of soil fertility and of peat, have combined in recent years to turn attention to the use of peat, both as a soil improver and as a propagating medium.

Peat and muck are often used interchangeably. Peat is the partly carbonized organic residue produced by the laying down of successive generations of plants growing in standing water. The submerging of roots, trunks of trees, twigs, seeds, shrubs, mosses, sedges and grasses prevents decay in a manner characteristic of tillable soils.

The reduction of air acts as a preservative and produces incomplete decomposition. Peat contains a large proportion of carbon of the original vegetable matter and its structure is readily observed without the aid of a microscope. It is usually acid and contains a very small percentage of mineral matter, sometimes as low as 4 per cent. Muck contains a high percentage of uncarbonized organic matter and presents a further stage of decay.

Sold commercially, peat comes as a soft brown colored material, dried and easy to handle. It is free from fungi and weed seed, highly absorbent and retentive of moisture, rich in organic matter and possesses a comparatively high nitrogen content (from 0.98 to 3.5 per cent, depending upon its source). It is further characterized by its seemingly antiseptic and insulating effects, which prevent decay, and its property of mellowing soils. Dried peat contains two to three times the nitrogen which is found in the average manure, but its phosphorus and potash contents are very low, even lower than those of manure.

Peat has been used in the United States as a fertilizer since 1908. Because of its deficiency in phosphorus and potash, these materials have been added to peat for commercial sale. It has been treated with nitrifying bacteria and applied directly to the soil as a fertilizer, or has been screened and used as the nitrogen supplying ingredient of some patented fertilizer mixtures. Strongly acid, raw peat has been recommended in the cultivation of many ericaceous plants.

A number of workers have indicated that because of low decomposability, peat remains inert for many years and is, therefore, valueless for most plants. Work at this station has indicated, however, that addition of cellulose decomposing bacteria, either by direct application or by the addition of small quantities of stable manure, has

resulted in such striking stimuli as to lead to the belief that nitrogen is given off early and rapidly.

Acidity must also receive consideration. The peats used in most instances are acid, and are beneficial from that standpoint. Ericaceous plants, like Rhododendrons, Azaleas, etc., are acid-living, while many others are acid tolerant. As a consequence, the introduction of acid peat into the soil has a beneficial effect. Soils may be acidified by the use of aluminum sulphate, but its continuous application may lead to formation of compounds injurious to plants, while the use of acid peat is safe.

Dachnowski has placed the peats in four distinct classes: the deep water, marsh, swamp and bog. The aquatic peat is produced by the deposits of water plants growing in ponds and shallow lakes. The marsh peat is composed largely of sedges and other grasses which have supplanted the vegetation of deeper water. The swamp class includes decomposed forest litter. The bog deposits produce our sphagnum moss peat, which is lower in its nitrogen content than the others, but is useful for many purposes nevertheless.

The soil problem of the greenhouse is distinct from any other phase of plant growing. Culture under glass is highly intensive, requiring rapidity of growth, yield and quality, consequently the most advanced economical methods are necessary. The desirability of avoiding yearly removal of soil from benches brings up the problem of renovating this soil without the labor and cost of removal. Peat combined with a small portion of manure promises to be a partial solution of this problem.

Green Manures

The use of green manures dates back to days of antiquity. At the present time this practice is part of a well established system of soil improvement and management in many establishments. Green manuring affects

the plants indirectly and directly. The succeeding crop is influenced directly and indirectly, the physical texture of the soil is improved. Certain ingredients are actually added to the soil. Leguminous plants augment the nitrogen content of the soil, while the other mineral components are turned back to it. Upon their return, they make close union with organic materials and become quickly available as decay sets in. As cover crops, green manures take up the extremely soluble elements and prevent their leaching from the land. In addition to this, the deeply rooting crops tend to bring up food materials from the subsoil and thus place it within easy reach of the new crop. The bacterial content is increased and aeration and drainage are improved. Even though, as in the case of manures, the actual amounts of nutrients which are added are not great, the indirect effects are of extreme importance.

The crops generally suitable for green manuring are cowpeas, soy beans, vetch, crimson clover, red clover, sweet clover, alfalfa, rye, oats and buckwheat. The last three are used for their abundance of easily decaying vegetable matter and for their adaptability to all types of soil, while the former are legumes and as such add nitrogen to the soil. Outdoors the choice of a cover crop depends upon the rotation and other factors. Alfalfa and the clovers are specially suited to long time rotations. Of the non-leguminous crops, rye is the most satisfactory because of its adaptability to light types of soil, rapid growth and resistance to cold. Green manures do not make the soils acid.

COMMERCIAL FERTILIZERS

The term, commercial fertilizers, is used to distinguish the chemical plant nutrients (sold in powdered form)

from barnyard manure. These commercial fertilizers are chemical or mechanical combinations composed of various materials essential for plant growth. Prejudice against the use of the so-called "chemicals" has been very general but is gradually disappearing as greater familiarity is manifested with their effects and the tendency to overdosing is eliminated. Many fail to appreciate that these materials are extremely concentrated and are useful only when applied in dilute form. Overdoses are disastrous.

ORGANIC NITROGENOUS MATERIALS

The sources of nitrogen are either of organic or mineral origin. The organic materials which are rich in this element are numerous, but those of chief importance are dried blood, tankage, bonemeal, horn shavings or meal, dried ground fish, cottonseed meal and tobacco stems.

Dried blood contains 9 to 14 per cent nitrogen. It is quickly available to plants in warm soils. Because of its organic origin, toxic effects have been observed from constant applications. Applied at the rate of three to five pounds to every 100 square feet, three or four times a year, it is very useful.

Tankage consists of the refuse materials from packing-house products. Its composition varies from 6 to 10 per cent nitrogen and 4 to 12 per cent phosphoric acid. It is not quite as quickly available as dried blood and may be applied at a slightly higher rate. As a steady dosage it is not recommended, but applied twice a season it becomes exceedingly desirable.

Steamed bonemeal is commonly used for its phosphorus content, but it contains from 1 to 3 per cent nitrogen in a quickly available form.

Horn shavings and meal, when used for their nitrogen content, are good fertilizers. They contain 10 to 15 per

cent nitrogen in readily available form. The phosphorus content is very slowly available.

Dried ground fish is used near the fish packing industries. It is about as desirable as horn shavings, with a nitrogen content of 6 to 10 per cent and 4 to 8 per cent phosphoric acid.

Cottonseed meal contains 8 to 9 per cent nitrogen and is used for plants which grow best in acid soils.

Tobacco stems are useful, although the nitrogen content is low (2 to 4 per cent).

INORGANIC NITROGENOUS CARRIERS

The mineral or synthetic products which are used for their nitrogenous composition, include nitrate of soda, ammonium sulphate, calcium nitrate, urea, ammonium nitrate, potassium nitrate. The two most important commercial inorganic materials have been nitrate of soda and ammonium sulphate.

Nitrate of soda or Chile saltpetre contains 15 per cent nitrogen in quickly available form. It has a tendency to produce an alkaline reaction under constant applications and, where water and soil both show the same tendency, its repeated use is not recommended. For safe usage, liquid forms are to be preferred at the rate of one ounce to two gallons of water; if applied in dry form, two pounds to every 100 square feet is sufficient. The long continued use of this material without an abundance of lime in the soil, is apt to leave a residue of sodium carbonate which is harmful to plants. In benches where the crops do not remain for any great length of time, the danger from this damage is negligible. The same holds true of its application to outdoor plants.

Ammonium sulphate, a by-product of coke manufacture, contains 20 per cent nitrogen. In cold soils it does not become as quickly available as the nitrate of

soda, but on warm soils there is little difference in effect. In direct contrast with the other, ammonium sulphate ultimately produces an acid reaction. Since many of our soils are alkaline there is no objection to this action. Ammonium sulphate comes in a form of grayish material and can be easily applied either in dry or liquid form. Because of the high concentration the liquid form is preferable for greenhouse crops, used in the same ratio as nitrate of soda. Likewise, the dry applications may be of the same strength.

Calcium nitrate is a very soluble synthetic product, containing 15 per cent nitrogen. Since about 28 per cent lime is left as a residue after the nitrates are used, the material may be objectionable with crops that are acid tolerant. This effect is particularly noted upon Chrysanthemums. The rate of use is similar to that of nitrate of soda.

Urea, as we ordinarily know it, is the main constituent of urine and as such is valuable in liquid manure. At present it is synthetically prepared by bringing together pure synthetic ammonia and carbon dioxide under high pressure. It is the most concentrated of all nitrogenous materials, with nitrogen content of 46 per cent. Its solubility and neutral reaction make it a very desirable substitute for liquid animal manures. Because of the extreme dilution which is necessary and consequent small amounts used, the fertilizer is comparatively cheap. In the greenhouse it should be used only in liquid form, at the rate of one ounce to 10 gallons of water; or if used in dry form, out of doors, applications of one pound to 100 square feet or about 50 pounds to the acre are sufficient. Since it leaves no objectionable residue, continued use is not harmful, and it is recommended in place of animal manures in liquid form.

Ammonium nitrate contains 36 per cent nitrogen, and is rather desirable except for its qualities of absorbing moisture from the air and its explosive properties, which make storage of the material somewhat difficult. It is highly soluble and should be used in liquid form only.

Potassium nitrate contains 14 per cent nitrogen and 45 per cent potash. Where both potash and nitrogen are required, as in the case of muck or peaty soils, or even upon sandy loams, this fertilizer presents a suitable combination. It is readily soluble and may be used either in dry or liquid form. In liquid form the rate of application should be similar to nitrate of soda, while in dry form it may be even higher. Several other synthetic products are now manufactured which contain combinations of nitrogen and potash or nitrogen and phosphorus. Where high concentrations are used, these materials will doubtless replace those of lower concentrations, since they permit economy in shipping and application.

Sludge. Modern methods of sewage disposal have developed another source of nitrogenous food in the form of activated sludge which contains 6 per cent nitrogen, and small amounts of phosphorus and potash. Experiments indicate that this material may be of considerable service to the grower because of its cheapness and availability of nitrogen. Increase in production, as well as better quality, have been recorded upon Carnations and Roses so treated. The rate of application may be 5 to 10 pounds to 100 square feet.

PHOSPHORIC FERTILIZERS

Many of our soils are deficient in phosphoric acid, and since manure is also low in this element, the addition of phosphates to the soil is usually attended with increased production and general betterment of growth. The prin-

cipal sources of phosphorus from the standpoint of florists and gardeners are superphosphates and bonemeal.

Superphosphates (acid phosphate), 16 to 20 per cent phosphoric acid, form the best and cheapest materials for applications to crops of short duration. The form in which phosphorus occurs in superphosphates is water soluble to a large degree, so that its application should be made before the crop is planted. After this material has been in the soil for a short time, it enters into various combinations which reduces its solubility, but is still gradually available to the plants. It may be applied at the rate of 5 to 25 pounds to 100 square feet, depending upon its deficiency in the soil. It is claimed that lime should be added to the soil to render superphosphates more available, but experiments conducted by the writers fail to justify such statements, particularly in neutral or alkaline soils.

Bonemeal contains 23 to 25 per cent phosphoric acid in extremely unavailable form, and because of that it should be used only for continuous effects of long duration. It should be applied in the Fall to soils which are to be cropped in the Spring, and for use in the greenhouse bonemeal is of value when added to the compost pile at the time of its preparation, or to the field just before manure application in the Fall. Immediate results cannot be expected, and the practice of applying this material for short season crops is a mere waste of time and money. In the same category may be placed horn shavings and hoof meal, if it is desired to get phosphorus from them. Tankage contains phosphorus in a similar form, and for that reason is not particularly helpful from the standpoint of phosphorus addition.

Boneblack contains 32 to 35 per cent phosphoric acid and one to two per cent of ammonia. This material is used occasionally in greenhouses.

POTASH FERTILIZERS

Unleached wood ashes are desirable from their potash content. They contain 3 to 7 per cent potash, a trace of phosphoric acid and 30 to 35 per cent calcium. The high calcium content enables the wood ashes to act as neutralizer of acidity as well as to supply potash fertilizer.

Potassium sulphate and potassium chloride are the principal potassic fertilizers. They are used in mixtures or alone with equally satisfactory results. Applied at the rate of three pounds to 100 square feet of ground, adds a sufficient amount for the needs of most plants. Since they are soluble rather quickly, applications should not be made too far in advance of planting.

FERTILIZER MIXTURES

At the present time many brands of fertilizers are on the market. Because of the strict enforcement of laws in various states, and the keenness of competition, the printed formulae represent what they actually contain. It is true that some are better than others, due to the fact that the materials of which they are composed have been chosen with care so as to combine them properly not only in a mechanical way, but chemically as well. Knowledge and experience are necessary to produce proper combinations, and for that reason home mixing of fertilizers is not advocated.

A 4-12-4 formula means that the fertilizer contains 4 per cent nitrogen, 12 per cent phosphoric acid and 4 per cent potash. On this basis a ton of this fertilizer contains 80 pounds of available nitrogen, 240 pounds of phosphoric acid and 80 pounds of potash, totaling 400 pounds of these ingredients. The question arises at once as to what composes the other 1600 pounds of the ton. It does not necessarily mean that a filler is used, although in the

cheaper grades we must expect several hundred pounds of inert material which serves no other purpose than making up the total weight. In the higher grades of mixed fertilizers no filler is used. For instance, in the making of 4-12-4, ammonium sulphate may be used to supply the nitrogen. Since this material contains only 20 per cent of this element, it is necessary to use 400 pounds to secure the needed 80 pounds of available nitrogen. Similarly, to secure 240 pounds of phosphoric acid requires the use of a 20 per cent superphosphate, of which 1200 pounds is needed to give the required 240 pounds. Finally, 400 pounds of potash bearing material which contains 20 per cent potash or 200 pounds of 40 per cent material are required to obtain 80 pounds of potash. The remaining 200 pounds are made up with filler of inert material. Many good mixtures are so compounded as to contain elements in different states of availability, and in this manner the fertilizer is used gradually and more beneficially. A number of higher priced mixtures are made in this way.

The tendency at the present time is to produce highly concentrated mixtures, to save expense in shipping, handling and applying. Of course, with such mixtures great care must be exercised to prevent overdosage. One of the most outstanding of these commercial preparations is one with a formula of 15-30-15. A good standard for most purposes is a 4-12-4 mixture which is being sold under a number of trade names. Although the formula is practically the same in these various brands, the manner of manufacture and source of material determines the desirability of one over another. Relatively high grade fertilizers cost less than those of low grade, because of higher concentration per unit weight. In the discussion under the different crops the most suitable formulae will be indicated.

SOIL ACIDITY AND AMENDMENTS

Soil acidity may be due to various causes, among which improper nutrition is of importance. To correct such conditions lime is added. Lime not only sweetens the soil, but also makes elements available by unlocking, as it were, the combinations in which they are and releasing them for the use of the plant. Iron is considered an exception to this. Lime produces lightening effects on clay soils and binding effects upon sandy soils. It favors the development of friendly bacteria which are necessary in the process of changing the unavailable nitrogenous compounds into nitrates or soluble forms. It counteracts the toxic effects of certain combinations in the soil. It is not a fertilizer in the true sense of the word but an amendment or ameliorator of the soil.

FORMS OF LIME (CALCIUM)

The forms of lime used in soils are: calcium oxide—quicklime, water slaked lime—calcium hydroxide, air slaked lime—calcium carbonate, ground limestone, marl and gypsum, also known as land plaster (calcium sulphate). Quicklime and water slaked lime have markedly alkaline reaction and neutralize soil acidity very quickly. The plant nutrients, nitrogen in particular, are liberated quickly and may be lost before they can be used. Since these forms of lime induce rapid decomposition of organic matter, their use in the greenhouse is not advisable. Air slaked lime produces less pronounced effects than quicklime. Limestone, finely ground, is the best form to use. It is rather slow in its action, but is safe and cheap. Air slaked lime, marl and limestone may be added to the soil, if needed, at the rate of 10 pounds to 100 square feet; water slaked lime, seven pounds; and quicklime, five pounds. The use of lime on freshly manured ground or

on piles of fresh manure is undesirable. Loss of nitrogen is likely to occur.

Lime should not be applied in quantities sufficient to neutralize the soil completely. Changes in the ingredients used as fertilizers may necessitate the addition of lime. Heavy doses of ammonium sulphate applied year after year will ultimately necessitate the addition of calcium. However, if ammonium sulphate is used in combination with superphosphate, no liming is needed.

In general, lime requirements should be fully determined before applications are made; this may be done through the use of litmus paper or, still better, by the application of Soiltex. This material may be secured from Agricultural Experiment Stations or from several fertilizer manufacturers. The test consists of taking a piece of waxed paper and placing enough soil on it to cover the space of a dime. A few drops of the greenish liquid are then added. After the soil has become saturated, it will turn blue or yellow in varying shades in accordance with its reaction. An accompanying chart indicates the degree of acidity by comparison with the color of the soil, and at the same time states the amounts of lime needed if the soil is acid.

Land plaster or gypsum is used very little, although in former years it anteceded the use of lime for soil correction. Only where the land lacks sulphur may its use be advisable, and even then, since the sulphur occurs in acid form, it may be troublesome.

ACIDIFYING SOILS

As a direct opposite to the use of lime, we have many plants that prefer acid soil. Many of these plants belong to the heath family and include Rhododendrons, Azaleas, Mountain-laurel, etc. Experiments have shown that aluminum sulphate applied at the rate of one half pound

to a square yard, mixed with the soil and watered well, will produce the needed acid condition of the soil. The same material may also be used in changing alkaline or hard water in the greenhouse by application of small amounts to the water tank. It has been used in the soil for changing the pink flowers of Hydrangeas to blue. Sawdust, spent tanbark, peat and acid leafmold used as mulches will maintain the soil in an acid condition when needed. As a fertilizer for the same conditions, the following mixture is suggested: cottonseed meal, 10 pounds; superphosphate, 4 pounds; sulphate of potash, 2 pounds. This may be applied at the rate of one pound to 50 square feet.

SOIL STERILIZATION

Soil sterilization serves the purpose of ridding the beds and benches in the greenhouse of various injurious insects, fungi and bacteria. Weed nuisance is reduced by the killing of the seeds. Precautions must be taken to prevent the contamination of the soil after treatment. Infected tools, contaminated footwear and addition of manure after sterilization may produce a more serious condition than existed previously. The numerous organisms contained in the soil are killed so that when recontamination takes place the pests have no competition in their struggle for existence, and consequently develop at a greater rate. A striking instance of this was shown by a large Chrysanthemum grower who was troubled with wilt. Upon the advice of his Experiment Station he sterilized the soil, but much to his consternation, the disease was more virulent than ever. He was through with new-fangled ideas. Upon examination, it was found that in every case after sterilization he added manure, which was contaminated, and, besides, used plants from the field which were showing unmistakable signs of wilt.

Usually, in addition to the beneficial effects secured from the destruction of the various pests, soil sterilization often increases the availability of some of the essential elements. Nitrogen, phosphorus and often potash are liberated. In many instances greatly increased growth results, although some cases have been observed where toxic elements have been liberated and subsequent crops suffered thereby. Extremely fertile soil may produce such effects. Steam, through the heat furnished, is the most satisfactory mode of sterilization. Chemicals are sometimes used with desirable effects, but usually they either fail to kill all the organisms or leave injurious residues. Corrosive sublimate is one of the chemicals used for this purpose. It is not effective in reaching the lower strata of the soil, but may be used for surface infestations. The concentration used is one ounce to ten gallons of water. One gallon of the solution will sterilize about twenty square feet of space. In addition, a number of other mercuric compounds are used. Semesan, Uspulun and Bayers Dust are the most important of these. They are effective against such surface infestations as "damping off." Copper sulphate, used at the rate of one pound to twenty gallons of water, is also effective for similar disinfections. Sulphuric acid is used to combat the same disease upon forest tree seedlings. One-half an ounce of acid should be added to every square foot of seed bed and daily watering provided. Sodium cyanide used in combination with ammonium sulphate has proved very efficient in ridding the soil of such serious pests as eelworms (nematodes). The dosage suggested is three ounces of sodium cyanide and four and one-half ounces of ammonium sulphate to the square yard. The cyanide should be dissolved in water and then poured on the soil until it is soaked to the depth of eighteen inches. The ammonium sulphate should be applied at once in liquid form to accel-

erate the decomposition of sodium cyanide and liberate the hydrocyanic gas fumes which kill the insects. If the ventilators are open, the fumes will not inconvenience the operator, but precautions must be taken because the material is deadly poison.

Formaldehyde may be employed when steam is not available. It is quite effective against most of the pests, but rarely kills all the nematodes. The most efficient dosage is one part of commercial formaldehyde diluted in fifty parts of water and applied at the rate of one and one-half gallons to every square foot of soil. After the application, a covering should be placed over the beds to keep the fumes in for twenty-four hours. Upon removing the cover, stirring of the soil should be practiced to permit the escape of fumes. Ten days at least should elapse between the treatment and the use of the soil for plants or seeds.

The most economical and permanent method of steam sterilization is by means of four-inch drain tile placed at a depth of 16 inches, so that the top of the tile is 12 inches from the surface of the soil. The distance between lines of tile should be 18 to 24 inches. Perforated tile gives better distribution, and when laid the joints may be covered with waste rags. This insures the forcing of the steam through the openings in the tile and its even flow to the ends of the houses. At the further end of each tile a vent may be left open. Where sufficient pressure is obtainable, steam should be passed into all the tiles simultaneously through pipes which enter the tile from the main flows. The length of time required for thorough sterilization depends upon the pressure employed. Eighty to ninety pounds of pressure will sterilize the soil thoroughly in one hour, if continued after the temperature at the surface of the soil has reached 140 to 180 degrees. With lesser pressures, greater length of time will be needed.

With thirty pounds of pressure, four to six hours will be necessary. The length of time may be reduced if a covering is provided over the beds which keeps the steam confined in the soil and permits only a small quantity to escape into the air. Plowing or spading of beds before steaming takes place permits rapid and uniform distribution of heat throughout the soil.

Steam pipes are often used in place of tile. They are perforated and laid in a manner similar to the tile. Because of the tendency to rust and high initial cost, as well as a large amount of labor required for the operation, they are objectionable. However, they are often used in sections, each section being moved from place to place after the work is accomplished. The danger of contamination is great and the purpose for which this method is intended is often defeated.

Galvanized iron pans are often used in many greenhouses. Steam pipes are inserted under the pan, which covers the bed or bench. These pipes are connected to the steam lines by means of a special steam hose. To prevent contamination when lifting the pan from one spot to another, large establishments have provided them with wheels which run upon tracks or sides of raised beds or benches. With this system the pans may be made of heavy material and thus withstand high pressures. It usually requires one hour to sterilize the soil in raised benches, but for beds the time is greatly increased. The method is not as efficient for beds as the tile because of the small space sterilized at the time, and the impossibility of securing adequate penetration. For sterilizing soil in benches and in flats the pan method is quite feasible.

The steam rake method also involves moving from place to place and is cumbersome. The rake is shaped somewhat like a harrow. The cross pieces are made of hol-

low pipe to which are attached smaller pipes ten to twelve inches in length. The rake is forced into the soil and the steam admitted into it from the main lines. Much of the steam escapes along the small pipes instead of penetrating, and consequently, this method is not efficient.

CHAPTER IV

FLOWERING CROPS

THE recommendations contained in this chapter are based on the assumption that soils in raised benches are changed either yearly or for every crop. The cost of changing soil in ground beds every year is high and the operation impractical. Under such conditions, manuring of the beds and the addition of superphosphate should be practiced once a year and should be followed by sterilization of the soil. Roses, Carnations, Sweet Peas and other crops produce very satisfactory results for many years when grown in ground beds and treated as suggested.

Although it is advisable to change bench soil for every crop, it sometimes becomes necessary to retain the old soil and grow several crops before refilling. When Snapdragons, Sweet Peas, Calendulas and others follow Chrysanthemums in the Fall, it may become impracticable to refill the benches either because of the cost or the unavailability of fresh material. In such cases, the best procedure is to incorporate one-fourth well rotted manure with the old soil and add superphosphate (10 pounds to 100 square feet). Subsequent feeding will depend upon the needs of each individual crop. In many instances excellent results are obtained in this manner.

Roses

Because of the possibility of controlling conditions in the greenhouse, Roses may be grown upon a great variety

of soils. It is true that the general recommendations call for somewhat heavy loam mixed with one-fourth manure. However, lighter soils will answer the purpose quite as well, provided that the fertilization is given proper attention. The clays are very retentive of moisture and usually contain an abundance of potash. The lighter soils, in addition to lacking potash, are frequently poor in phosphorus and nitrogen.

"As fertilizing material in which to grow Roses there is nothing to beat good, fresh cow manure, if properly applied; when thoroughly incorporated into the soil it is safe to use at any time." This statement, made by a well known grower of Roses, is undoubtedly correct. Manure should be incorporated into the soil before the soil is placed in beds or benches. Its use thereafter may well be confined to an application once a year at the time that the Roses, after being dried off, are being started into growth again.

The feeding given in the interim should consist of applications of commercial fertilizers, which are easy to apply, dissolve readily and are inexpensive and very effective when used in proper doses. The manure which has been incorporated into the soil will provide the needed humus and the nitirifying bacteria. Its further use as liquid is generally recommended because of its safety, but actually the amount of nutrient materials supplied is so small and the inconvenience of handling this material is such as to necessitate recommendations for fertilizers in commercial form. In addition, scarcity of manure in many sections necessitates reliance on substitutes.

Since many soils are deficient in phosphorus, this must be added at the time of mixing of the soil and once a year thereafter. In former years this need has been met by the use of bonemeal. At present, superphosphate, either 16 per cent or 20 per cent, is being used in its place.

The reason for this change lies in the fact that bonemeal is less quickly available than the superphosphate and is much more expensive. Many weeks are necessary before the phosphorus from bone is useful to the plant, while in superphosphate part is available at once and the balance is released more gradually. From actual observation it is difficult to detect phosphorus starvation, but records of production will soon indicate the beds to which the material has been applied. Ten pounds of superphosphate to every 100 square feet often give marked increases in production. Such an application is equivalent, in phosphorus, to 1400 pounds of manure. Obviously, it would be difficult to add such a quantity of manure to the space of bench mentioned. Experiments have shown that overdosing with superphosphate is unlikely, while it is quite possible to cause injury by an overdose of bonemeal or tankage.

It is not to be assumed that phosphorus alone is the limiting factor in growth of Roses. The need of nitrogenous fertilizers becomes urgent after January and is apparent in the lighter color of the foliage, as well as lack of former vigor. Manure, in liquid (one bushel to a barrel or its equivalent), or in solid form, may be applied weekly or bi-weekly with safety, but if it is not procurable, a number of chemical compounds are at hand which will serve the purpose even better. Nitrate of soda or ammonium sulphate, diluted to one ounce to two gallons of water, once in two weeks, dried blood or tankage (5 pounds to 100 square feet) every six weeks, urea (one ounce to ten gallons) once in two weeks, give very satisfactory results. A number of desirable commercial mixtures are on the market. One of these, analyzing 4-12-4, has shown striking results when applied every four weeks at the rate of four pounds to every 100 square feet. Another, of much higher concentration (15-30-15), is used

at the rate of six pounds to 100 square feet twice a year and supplemented in the interim with urea. In the use of nitrogenous materials, it must be remembered that cloudy weather plays an important part in their non-effectiveness. During stretches of such weather, reduction of amounts or complete withholding is recommended.

Experimental data fail to show that in heavy soils additions of potash are conducive to any higher production or better quality. In light soils, the amounts contained in the above mentioned complete fertilizers will aid growth materially, but in heavy soils the 15-30-15 formula is not particularly desirable. Applications of potassium sulphate and potassium chloride have even resulted in decreased yields. Hardwood ashes may be used with safety, acting partially as a corrective for extremely acid soils.

The great need of phosphates in the soil precludes the use of lime. The solubility of phosphates is decreased in soils which are alkaline. Results have shown that decrease in production follows applications of lime. This may be due to the fact that most water supplies have an alkaline reaction and consequently further additions of calcium and magnesium in the form of lime will produce a strongly alkaline condition which may result in toxicity and injury to the plants. If green growth of algae appears on the surface, a mulch of peat will eliminate it. In addition, the nitrogen content of this material is a valuable asset.

In general, it may be said that large quantities of manure, applied either in liquid or solid forms, tend to promote soft, watery growth which is particularly susceptible to disease. They often cause a toxic effect upon the soil with subsequent rotting of many of the roots. The judicious use of commercial fertilizers tends to develop earlier flowers of good quality upon vigorous plants which are less likely to suffer from any neglect or disease.

Carnations

One of the chief problems in carnation culture is the preparation of the soil. Strong sandy loam provides the most suitable medium. In small establishments the compost will provide proper soil, but on a larger scale this method is not practicable. To provide a certain quantity of humus, to permit of aeration and to supply the needed elements for plant growth, green cover crops should be used in the soil destined to be used in the greenhouse. Soy beans or other legumes should be planted in the Spring and turned under in the Fall. Rye should follow this in the Fall and be turned under in the Spring. At this time, an application of bonemeal or superphosphate, at the rate of 600 pounds to the acre, should be made. Scraped to a depth of six inches, this soil will produce strong, luxuriant growth of Carnation plants in the bench. If the plants are grown in beds, which are not changed yearly, an application of a four-inch dressing of well rotted manure will be needed before the planting in August. This should be supplemented by the addition of superphosphate at the rate of 10 pounds to every 100 square feet of bench.

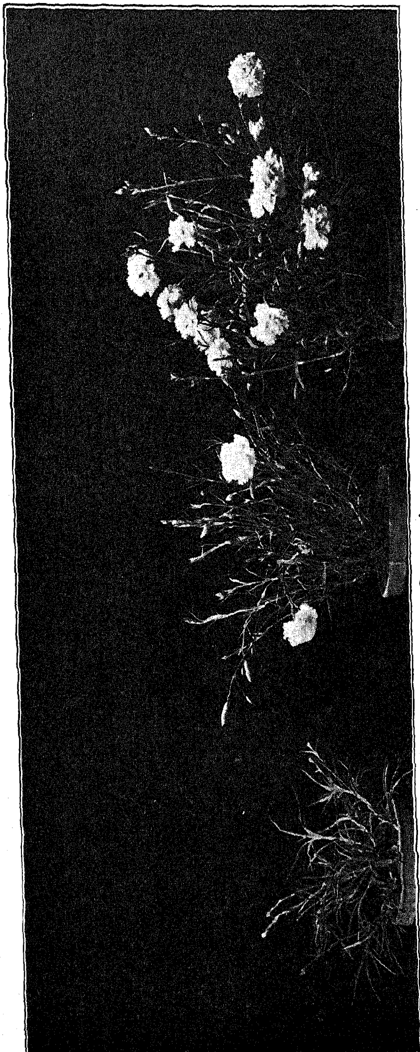
After two months in the greenhouse, the soil will have become exhausted sufficiently to necessitate applications of additional nutrients. Although earlier practice has withheld additional fertilizers until the dark days of Winter are over, experimental data show that light feeding should begin in October. This should be discontinued in December and resumed again about February 1. Liquid cow manure, mulches of sheep manure and cow manure have been the rule and, from the standpoint of safety, they are reliable although not the most effective means of securing the best quality and highest production.

The use of superphosphate at the time of planting (10 pounds per 100 square feet) has been conducive to

greater production, in some cases giving an increase of 16 to 20 per cent. In addition, earliness of flowering has been induced and splitting of calices reduced to a minimum. Bonemeal has also been used advantageously, but no results from it should be expected until the Spring crop. Its higher cost and lower availability make it less desirable than the superphosphate (16 per cent or 20 per cent).

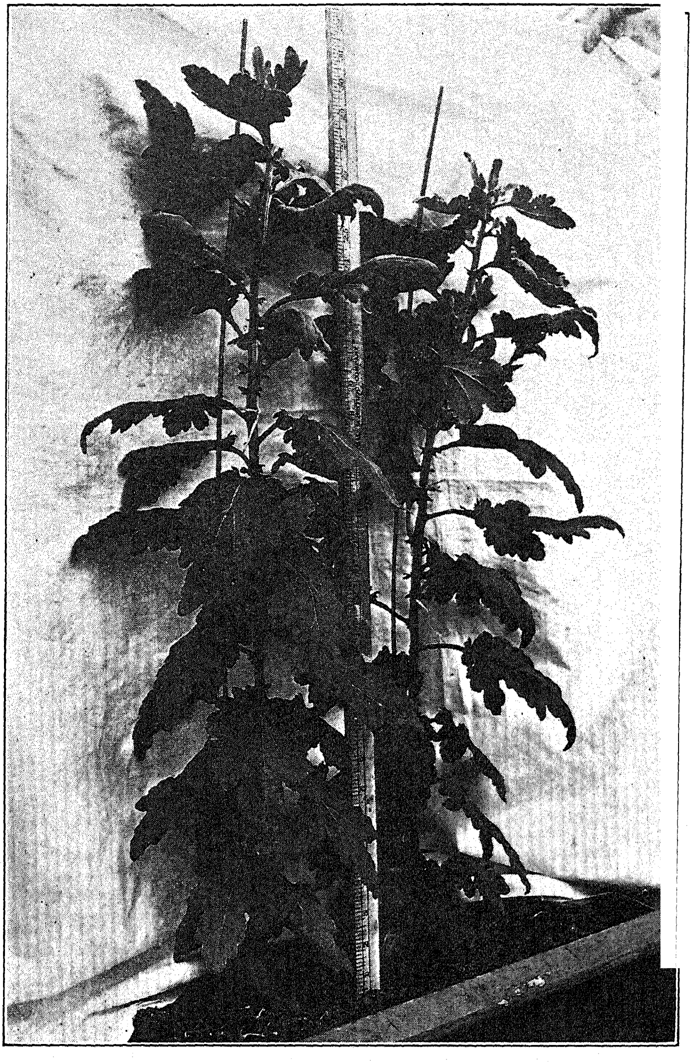
Experimental data and actual practices indicate further that the use of nitrogenous fertilizers should be deferred until after February. Since manure mulches and liquid manure provide nitrogen almost exclusively, their application is not advocated in the Fall. Blood and bone tankage applied in February (three pounds per 100 square feet) and followed by two other applications of similar strength during Spring, has been known to give extremely satisfactory results. Earliness of bloom in the Fall may be secured by the use of tobacco stems, applied to the benches as a mulch at the time of planting.

Among the commercial fertilizers, nitrate of soda, ammonium sulphate and urea have given increases in production. These should be applied in liquid form early in the Spring at bi-weekly intervals. Complete commercial foods, such as 4-12-4 and the stronger 15-30-15, have also proved of undoubted benefit. The applications of 4-12-4 should be made in October, then once a month from February until May. The rate of application should be one pound to 50 square feet of bench, in dry form. The more concentrated material (15-30-15) may be used as a substitute in liquid form at the rate of one ounce to 10 gallons of water once in two weeks. These mixtures supply the needed nitrogen in gradually available form and at the same time add the phosphorus and potash which may have become depleted in the soil. To sum up the recommendations: if the soil is well prepared and



Carnations

Check — Urea — 15-30-15



Manure Mulch and Superphosphate

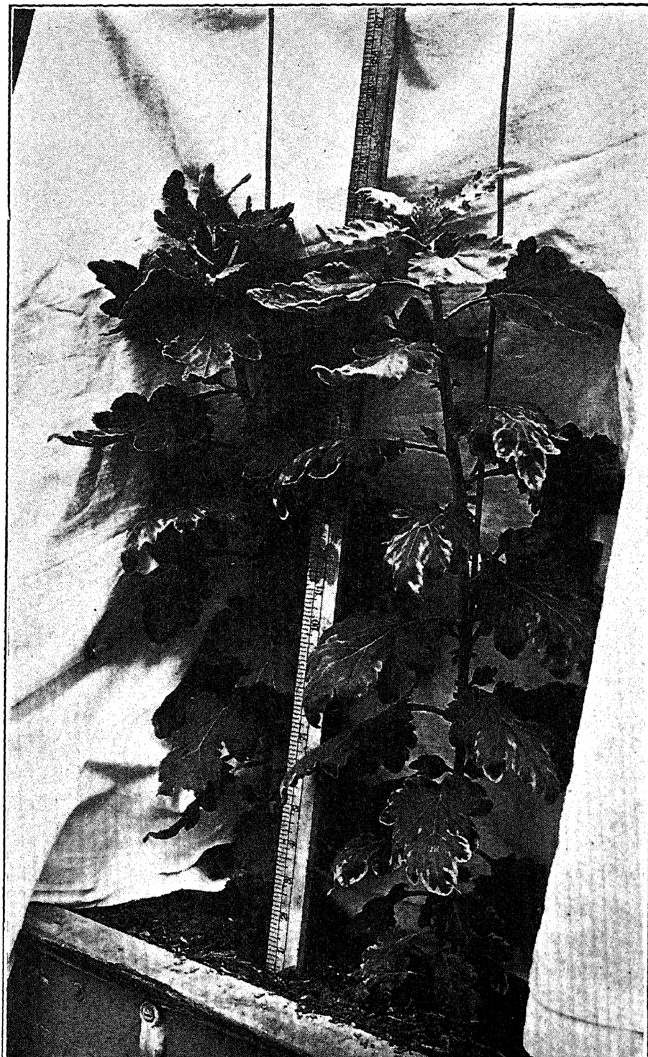
superphosphate is added at the time of planting, one application of a complete fertilizer should be made in October and another in November. In February another dose should be applied and followed thereafter with the same material every month, or liquid nitrogenous foods every two weeks.

Chrysanthemums

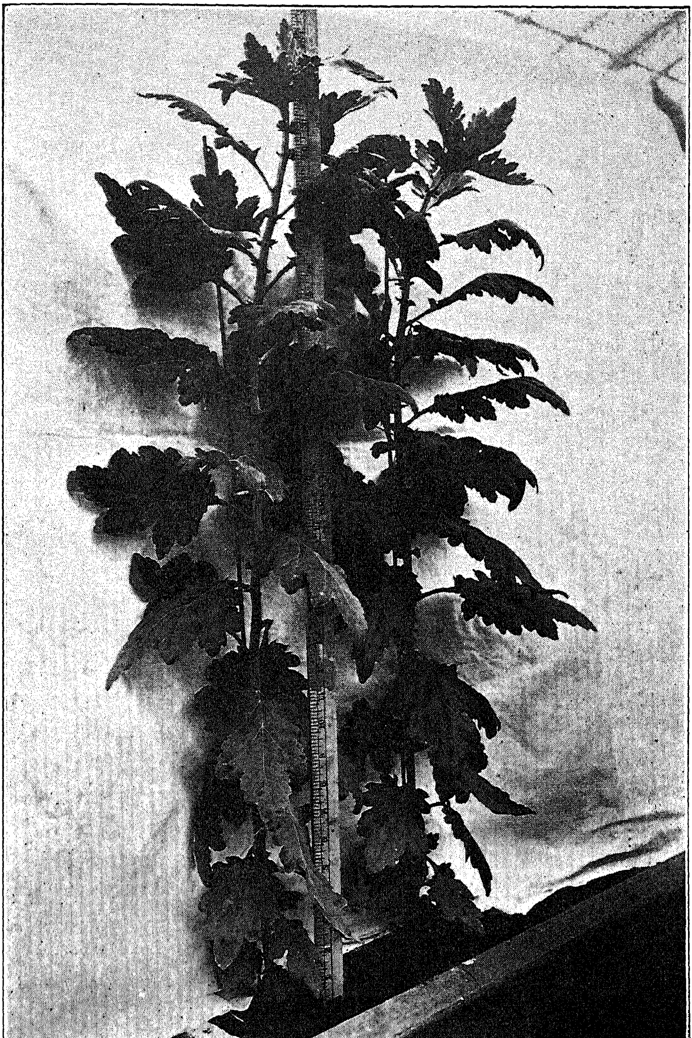
Fibrous sods cut three inches thick and piled grass side down the preceding Fall, with one-fifth their bulk of partially decomposed manure mixed in, make an excellent compost for filling benches. Fibrous loam, not too heavy, is preferable to clay loam. Chrysanthemums are heavy feeders and require rather rich soils to start. On large scale production, fresh cut sod may be placed one layer thick in the bottom of the bench and the rest filled with fibrous loam. Field soil prepared in manner similar to that used for Carnations is also suitable.

In the light of recent experience, the advice offered by some earlier writers needs revision. They advocate that no feeding be done until the buds begin to form, and then only in a form of a mulch of manure. They advise later application of liquid manure every two weeks.

Experiments conducted by the writer, and corroborated by actual practice in many commercial establishments, indicate that heavier feeding is necessary to secure the best results. The most striking manifestation has been with the use of foreign and domestic peats. These act as quick starters of growth. In a few weeks after planting, the plants to which peat has been applied as a mulch, one inch thick, show from 50 to 100 per cent increase in growth over those to which no application had been made. Peat contains a fairly high percentage of nitrogen, which is liberated through the action of the bacteria in the soil. The better moisture holding capacity



Manure Mulch



Peat added as Mulch

Difference of 11 inches between this and Check]Plot

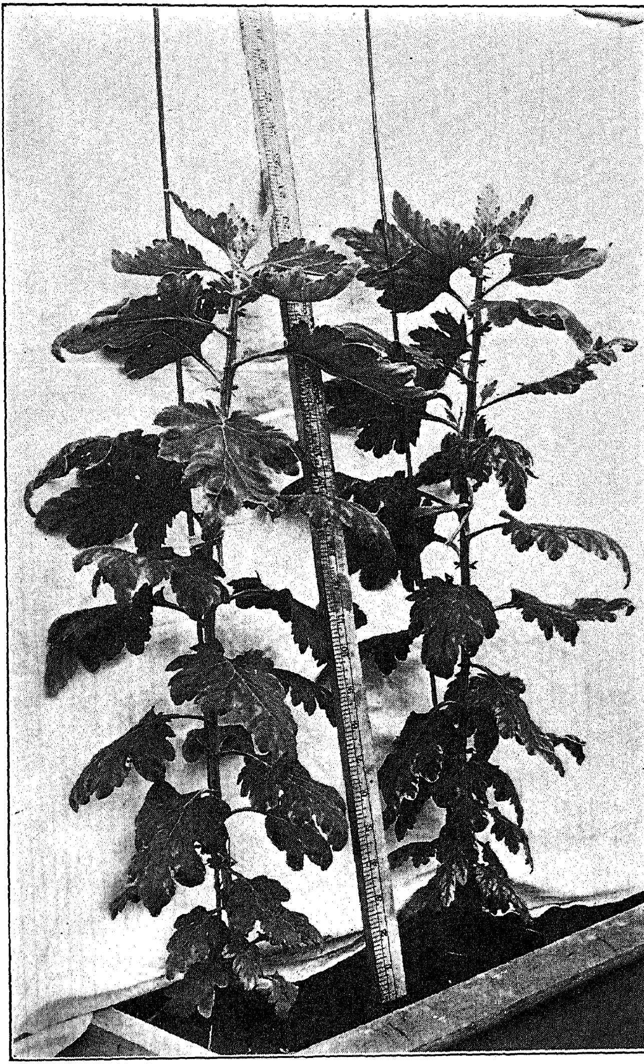
and the amelioration of soil texture due to the addition of peat, also play an important part in the greatly increased growth. The writer's work indicates also that a certain acidity in the soil benefits Chrysanthemums. Peats supply that. The increased vegetative growth produces better quality and larger flowers. The results obtained warrant the conclusion that peat alone may be supplied to the soil with better results than those secured by the use of manure as a mulch or in the form of liquid.

Superphosphate applied at the time of planting (five to ten pounds per 100 square feet of bench) has also been found to be very valuable in starting growth, and particularly in inducing earliness. In many cases a difference of ten days to two weeks is secured in the time of flowering. Applications of bonemeal to such a short season crop as Chrysanthemums have proven of no value.

Nitrogenous fertilizers should be used at the time of taking the buds and followed thereafter at bi-weekly intervals. Ammonium sulphate and urea are the most satisfactory. The former has a slight acid reaction, while the latter is neutral. Calcium nitrate and nitrate of soda are both alkaline and for that reason are not as efficacious.

Due to the fact that water used in the greenhouses is often hard or alkaline, the soils may become extremely alkaline and growth is reduced. To counteract this alkalinity, aluminum sulphate at the rate of one pound to 100 square feet may be used, or better still, a mulch of peat applied.

Commercial mixtures have been used profitably, although, if superphosphate is applied at the time of planting, there is a sufficient amount of phosphorus in the soil to last to the maturity of the crop, and usually there is sufficient potash in the soil to obviate the need of additions. The value of the complete fertilizers then would lie chiefly in the nitrogen that they furnish. This may



Check, Showing Yellowing Nitrogen Starvation

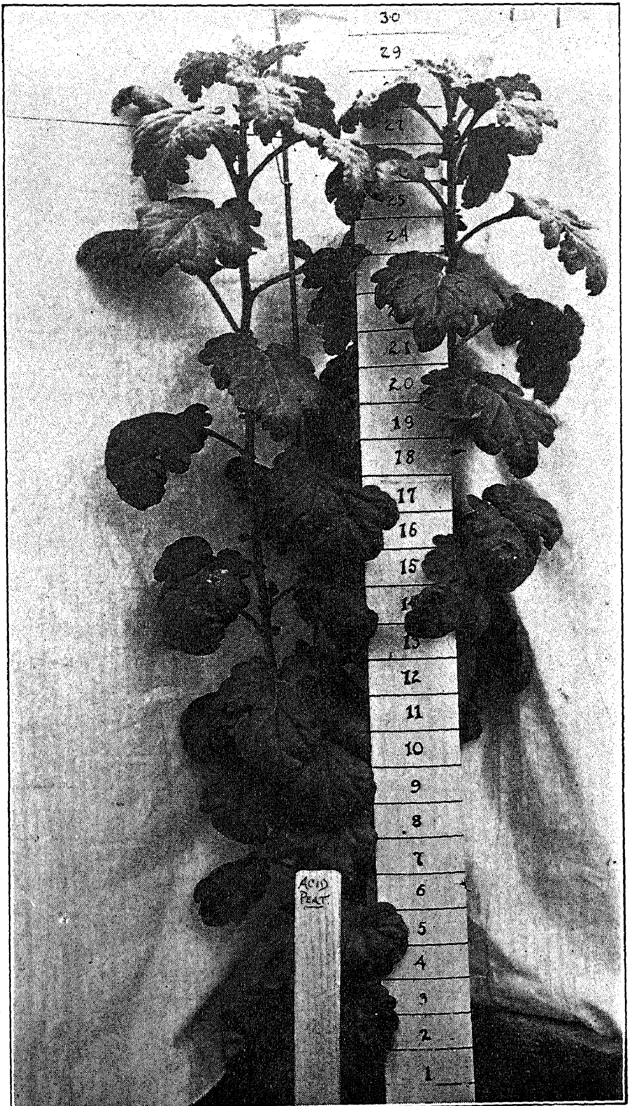
be secured from the direct nitrogen carriers as indicated above.

Overfeeding is a frequent fault. When a leaf is pressed between the thumb and finger and cracks and fails to return to its normal position, it is evident that fertilizing has been too generous. Overfeeding may cause some varieties to become "blind," *i. e.*, the internodes fail to elongate, and a compact mass of foliage at the top of the stem results. Feeding should be discontinued at once in such a case.

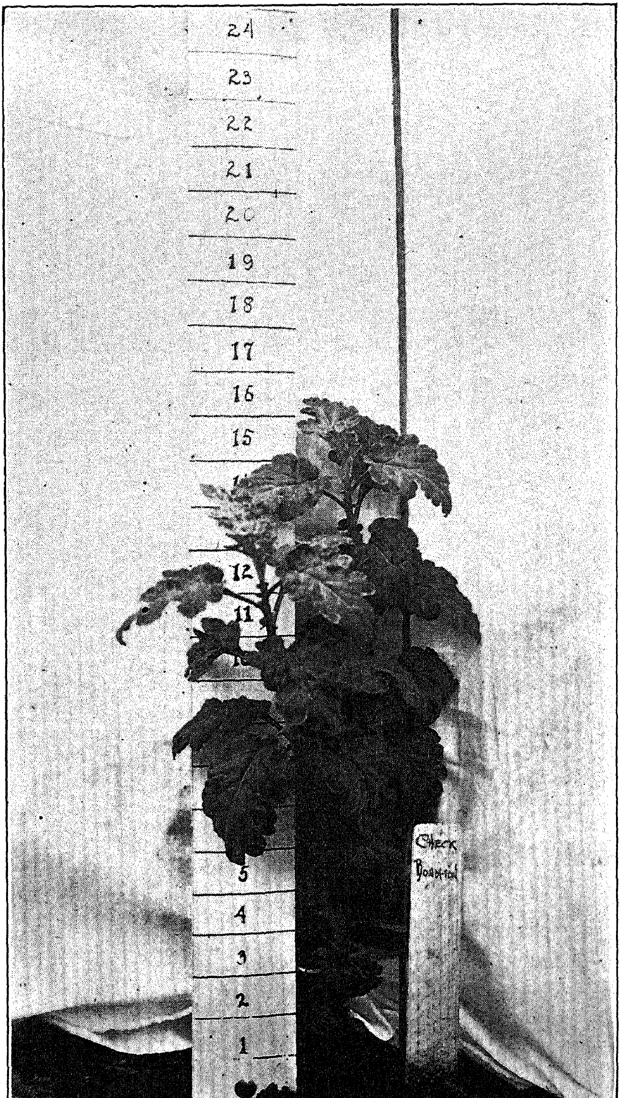
In general, if the soil is well prepared and superphosphate is added at the time of planting, no feeding should be attempted until the taking of buds. From then on, weekly doses of nitrogenous materials—ammonium sulphate (one ounce to two gallons), urea (one ounce to ten gallons), liquid manure or dried blood—should be applied. If commercial fertilizers, under various names, are desired, a dry application every two weeks will be found suitable. The 4-12-4 fertilizer should be applied at the rate of two pounds to 100 square feet of bench, and 15-30-15 at one-third that rate. The latter may be used in liquid form. It is apparent, however, that with an application of superphosphate at the time of planting, and a mulch of peat on top of the soil, no further feeding is necessary. Until buds are taken, peat is well worth a trial.

Sweet Peas

Well drained, mellow, deep, medium heavy soils are excellent for Sweet Peas. Because of the deep rooting propensities of the crop, depth of soil is of paramount importance. To secure this, trenching to a depth of three feet is often advised. At the bottom of the trench a heavy layer of well rotted manure should be placed and good soil filled to the top of the trench. Superphosphate should



Chrysanthemum Bonnaffon, Peat Mulch on Bench



Chrysanthemum Bonnaffon. No feeding

be applied at the rate of five to ten pounds to every 100 linear feet of trench and mixed with the upper layer of the soil. Bonemeal may be also used for the same purpose, but the results from it will be much slower.

Trenching is not necessary if the same resulting depth of good soil can be secured by spading or plowing of the ground beds. The point which must be remembered is that it is useless to grow Sweet Peas on poor, shallow, heavy, poorly drained, sour or thin soil. A certain amount of growth and flowering will result but it cannot be commercially profitable. Sweet Peas grow best in slightly alkaline soil. This requirement usually necessitates the addition of lime at the time of planting (five pounds to 100 linear feet).

After the vines have reached a height of 10 to 12 inches, light feeding should begin, particularly with the Fall and Spring crops. The Winter sown crop is growing under conditions of reduced light and may easily be overfed. Experimental results have shown that where the soil is well prepared, with superphosphate added, there is little need of additional fertilizers for the first two months. Later, however, a well balanced material, such as 4-12-4, may be applied along the trench every three or four weeks at the rate of two pounds to 100 feet of row. A 6-8-6 fertilizer also is suitable. These fertilizers are preferable to manure applications or to the use of highly concentrated nitrogenous materials, which induce soft growth, subject to disease and bud dropping. The phosphorus and potash in these mixtures tend to counteract the effects of nitrogen. In addition to this factor, the nitrogen in good commercial mixtures is in such form as to be given off slowly. This gradual action assures the grower of greater safety in applications and enables the plants to utilize the material as it is given off. At the end of the season, however, when the plants require a fresh stimulus,

applications of liquid urea, nitrate of soda, calcium nitrate or ammonium sulphate every two weeks will be extremely useful. The proper dosages have been discussed under previous crops.

Potash is an essential ingredient for the production of disease resisting plants. It is thought that streak and anthracnose diseases are reduced in their virulence if the soil contains an abundance of potash. Heavy soils contain this element, as a rule, but for light soils an application of commercial fertilizer, rich in potash, is desirable. The formulae mentioned above contain sufficient potash for ordinary soils, but extremely light media should receive an additional application of potassium chloride or potassium sulphate at the rate of three pounds to every 100 feet of row. Unleached hardwood ashes, 10 pounds to 100 feet, will answer the same purpose.

To grow Sweet Peas in shallow benches requires considerable knowledge in the art of feeding. The soil must be made rich at the start to make up for lack of depth. Fertility must be maintained by artificial fertilization. A layer of well rotted manure in the bottom of the bench is very helpful and, after the plants have made a growth of 12 inches, bi-weekly feeding becomes necessary. For this purpose, the mixtures mentioned may be used in dry form at the rate of two pounds to every 100 square feet of bench, or a 15-30-15 fertilizer may be added in liquid form, weekly, dissolved at the rate of one ounce to seven gallons of water, which amount should suffice for 50 square feet of bench. All the fertilizers will not help, however, if coolness at the roots is not maintained.

Snapdragons

The Snapdragon requires a thoroughly prepared soil with organic matter well incorporated and uniformly distributed. Light textured soils afford easier penetration

for the roots and are preferred to the heavy kinds. If, however, clays and clay loams are properly prepared, the color, substance and quality of the blossoms are usually better than in lighter media. In many instances, the Snapdragons follow Chrysanthemums in the Fall, the same soil being used for both crops. This procedure often results in stunting of the second crop because of the Chrysanthemum roots which remain in the soil and apparently produce a toxic condition. To secure more satisfactory results the soil should be changed after Chrysanthemums are removed.

At the time of planting, one-fifth of the volume of soil in the bench of well rotted manure and five pounds of superphosphate per 100 square feet per bench, may be applied. If this is done, little additional fertilization is needed during the Fall and Winter months.

As in the case of Chrysanthemums, a one-inch mulch of peat will be found extremely advantageous and will eliminate the need of further fertilization until Spring. This mulch may be applied in the Fall or late in the Winter. As high as 30 per cent increase in production has been secured with this treatment. Closely approximating the same results is the combination of superphosphate at the time of planting, followed late in the Winter by applications of urea in liquid form every two weeks. Ammonium sulphate may be substituted for urea. A number of commercial mixtures have also proven very useful; 4-12-4, at intervals of four weeks at the rate of two pounds per 100 square feet, has shown striking increases in production. On the other hand, additions of bonemeal, sheep and cow manure mulches have not proven worth while.

Excessive use of nitrogenous fertilizers during the Winter months is apt to result in fading of colors, drooping of the upper parts of the flower, succulent growth, which

becomes easy prey to rust and wilt and poor keeping qualities of the flowers. Lack of nitrogen is manifested by yellowing of the foliage and hardening of the tissues.

Violets

The single Violets grow well in moderately heavy soils, while the double varieties require heavy sod. The sod serves the double purpose of supplying the needed nutrients and of making the plant secure in its position, which becomes important at the time of picking. It is good practice to seed down the field upon which a cultivated crop had been grown and permit a heavy sod to form for two years. This sod should be plowed either early in the Spring or late in the Fall. Fall plowing is preferred, since it permits of breaking of the lumps and killing of insect larvae. Horse manure, to the extent of one-fifth the total volume of soil, should be incorporated at the time of planting. At the same time addition of superphosphate will be beneficial.

On a small scale, a compost is the best method of soil preparation. Subsequent feeding of plants is rarely attempted because of the fear of excess. In many cases, a mulch of horse manure is placed about the plants in November, but this may well be eliminated and a mulch of peat moss substituted. The amount of nutrients received in this fashion will be as great and the advantages of cleanliness and freedom from disease overbalance the added cost. Toward Spring, light applications of a complete fertilizer (4-12-4) are very beneficial. One pound to every 100 square feet of bench, applied twice in the Spring, will suffice.

Bulbs

Tulips, Narcissi, Hyacinths and Freesias, grown for cut flowers, require a rich compost. A good mixture consists of three parts medium heavy loam and one part well

rotted manure or leafmold. To this compost the addition of superphosphate at the rate of a four-inch potful to a bushel of compost is desirable. Since the substance of the bulb furnishes some of the food material for the production of the flowers, the materials in the ordinary potting soil suffice for the production of good flowers. Nitrogenous fertilizers, such as urea and calcium nitrate, may be used in weak doses, but unless care is taken "loppy" stems and poor keeping quality are likely to result.

Easter Lilies grown for cut flowers should be placed in flats containing a heavy compost. Incorporation of well rotted manure helps the quality and increases the production. Addition of superphosphate or bonemeal should be made at the time of planting and, later, when the bulbs are just showing, an application of a complete fertilizer should be given. Watering with liquid nitrogenous materials, once a week, may be practiced with success. Animal manure as well as urea, nitrate of soda, calcium nitrate, ammonium sulphate or 15-30-15 may be used for these liquid feedings.

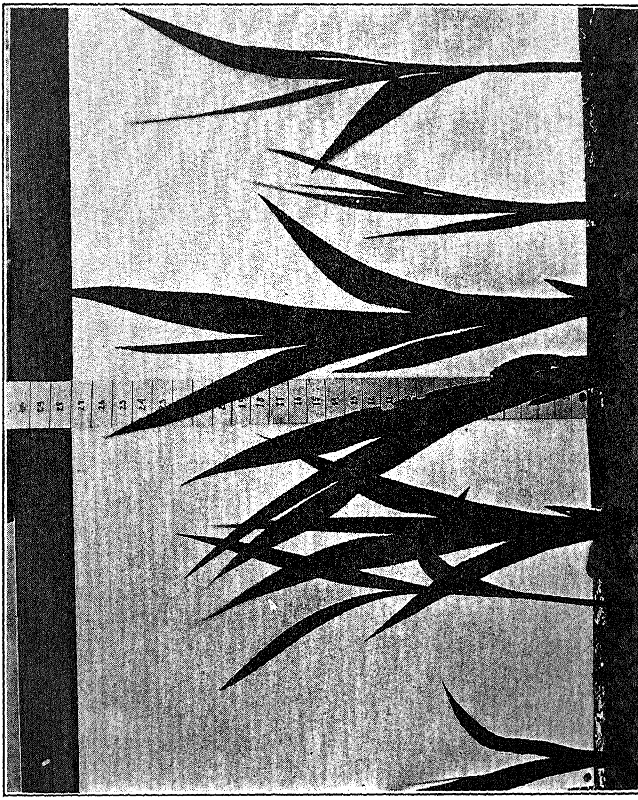
The Regal Lily responds to similar treatment, except that the soil should be light and contain one-fifth peat.

Bulbous Iris need no after feeding, provided that the soil used is a rich, sandy loam.

Gladiolus

The notion that any soil and but little care are necessary to force Gladiolus in the greenhouse is erroneous. Failures are often due to this fact. A well enriched, sandy loam, which has not been exhausted by a crop preceding the Gladiolus, produces an abundance of flowers, but a heavier soil, if properly prepared and drained, results in finer quality.

Recent experimental data indicate that superphosphate is important in the best development of the corms



Gladiolus
Superphosphate at Planting

as well as the flowers. It should be applied to the beds (10 to 20 pounds per 100 square feet) at the time of planting. The use of nitrogenous materials should be deferred until the spikes are beginning to form, which condition is indicated by the thickening of the stems at the base. Ammonium sulphate urea, or balanced materials, such as 4-12-4 or 15-30-15, may then be applied once in two weeks until the buds show color. The use of superphosphate induces earliness of bloom, while early application of nitrogen results in delayed blooming. Potash should be omitted from consideration except insofar as it is given in the complete mixtures mentioned. When applied early, it tends to inhibit growth of Gladiolus.

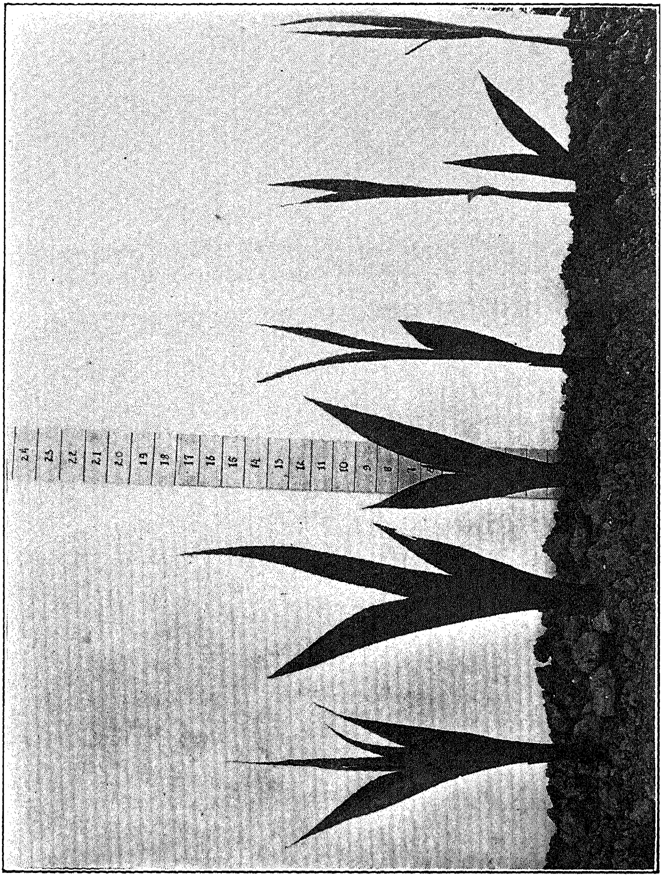
Fertilization itself and the use of good soil will not compensate for the planting of small, flat corms. Only high crowned, perfect corms should be used, and preferably those which have been produced on fairly heavy soil.

Miscellaneous Cut Flower Crops

Under this heading may be included Calendula, Gerbera, Stocks, Gypsophila, yellow Daisies, Stevia, Mignonette, Larkspur, Erlangea, Didiscus, Feverfew, Forget-me-not, Lupines and a number of other annuals and herbaceous perennials which are forced in the greenhouse on a small scale.

In most cases, a good compost of medium texture, such as is found desirable for Chrysanthemums, grows these crops satisfactorily. Since many of these crops require abundance of water, the soil should be retentive of moisture and yet porous enough to drain well. Gerberas flourish best in a light, sandy loam, while Calendulas do best in heavier types of soil.

Because of the short season of growth, additional feeding is rarely necessary, providing that the initial



Gladiolus, Check

preparation of the soil includes one-fifth manure and superphosphate in the usual rate. When buds begin to show, addition of a well-balanced complete fertilizer may be made. A second application should follow three or four weeks later: two pounds of 4-12-4 or 6-8-6 per 100 square feet will be helpful. In liquid form, 15-30-15 may be used every two weeks after the buds appear. These recommendations are made for the purpose of securing the best growth and development. If mediocre material is satisfactory, no additional nutrients need be given after the plants are in benches.

CHAPTER V

POT PLANTS

THE discussion of soils and fertilizers for pot plants must of necessity be handled from a different angle from that of cut flower crops. Most of the pot plants grown are short season crops, and in the frequent shifting to larger pots receive the needed nourishment. Accordingly, the fertilizers which are used should generally be applied to the potting soil, rather than to the pots after potting. However, when the last shift is given and the "finishing" process begins, additional nutrients should be applied not only for the purpose of increased size and quality, but also in order to hold down the size of the pot. Enriching the soil through the proper use of fertilizers reduces the need of unwieldy, large pots.

The recommendations that follow will be found useful only if care is used in the selection of pots, the thorough mixing of the soil and the fertilizers, the proper methods of potting and understanding of the other necessary requirements for the growth of plants.

The pot used should be porous and not too soft, to provide good drainage and at the same time to prevent the lodgment of fungi and bacteria. If the pot is soft and is used more than one season, it deteriorates, crumbles and exposes surfaces in which the pests multiply. Glazed pots are objectionable because of the absence of porosity and lack of aeration at roots. Fiber pots, peat pots and paper pots are only makeshifts and play no part in the

commercial growing of pot plants for sale as individual specimens. Sufficient drainage should be provided at the base either by one or more openings. This is further assured by the use of broken crocks, charcoal or even gravel at the bottom of the pots. All new pots should be soaked before use.

Since potting soils are all "made," the materials that compose them should be thoroughly mixed, particularly when fertilizers are added to these composts. When added in dry form, such materials as superphosphate and the complete fertilizers of low concentration (4-12-4, 6-8-6) should be added at the rate of one four-inch potful to a wheelbarrowful of soil, although superphosphate will do no injury if the amount is doubled. Such a potful is equivalent to approximately one pound of fertilizer.

The manual operation of potting is deemed so simple that it is often poorly done. Since the usual symptoms for the need of repotting consist of the plants being somewhat potbound with the new roots on the outside, it is essential that in the process of shifting, soil should be placed and packed well about the entire ball. Air spaces should not be left, which often happens when the shift is made from one pot into another just one size larger. Care in potting will avoid this trouble. Too large a shift is not advisable, because the amount of soil present is likely to become soggy and waterlogged with subsequent injury to the roots.

The fact that roots are confined in a small receptacle gives the grower of pot plants an advantage over the one who grows plants in benches or beds, because of the possibility of better control of the small amount of soil present. However, watchfulness is essential to prevent plants becoming potbound at undesirable periods. It is a common practice to cause restriction of roots (potbound) in order to produce profuse flowering, but if done

too early it causes stunting. Foliage plants should not be allowed to become potbound, otherwise yellowing of leaves will occur.

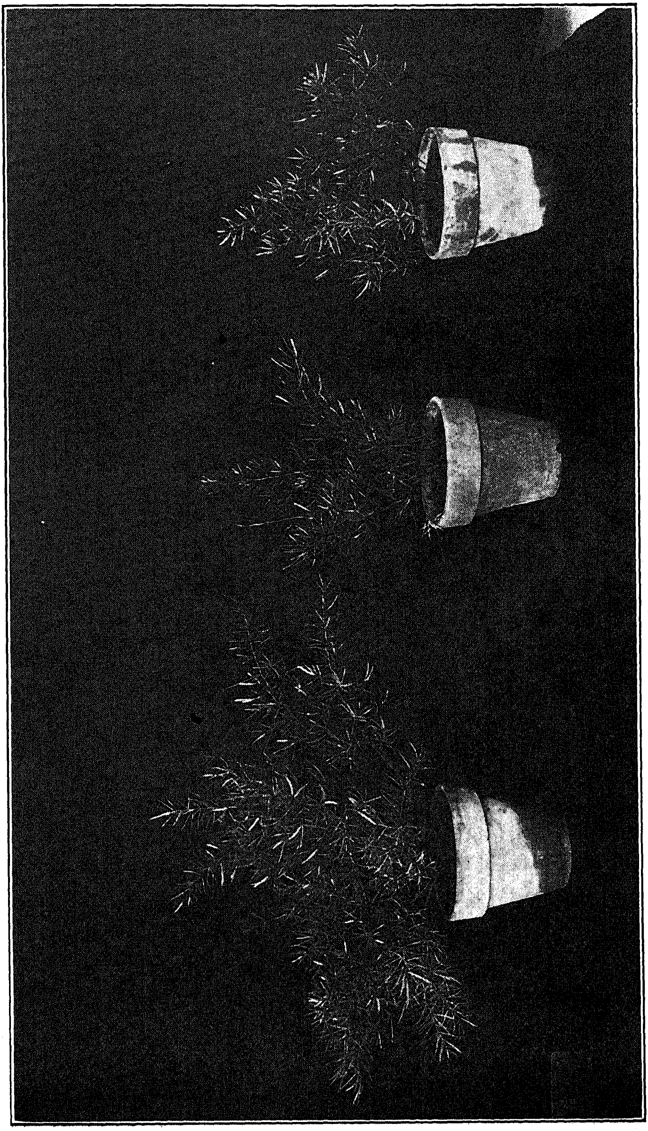
When fertilizers are applied directly to the pots instead of being mixed with the potting soil, the usual amount is one-half teaspoonful to a five-inch pot. Nitrogenous fertilizers should always be applied to potted plants in liquid form. In these applications care should be exercised to keep the chemicals off the foliage to prevent burning.

Adiantum (Maidenhair)

Fibrous, sandy loam, with one-fourth cow manure, leafmold or peat, is the most suitable soil for Maidenhair Fern grown for cutting. A mixture of three parts loam, one part peat and one part cow manure is still better and will produce an abundance of long fronds, providing other factors are favorable. Toward the end of the seasonal growth, a complete commercial fertilizer should be applied once or twice. A 4-12-4 answers the purpose admirably (two pounds to 100 square feet).

Asparagus plumosus and sprengeri

Asparagus plumosus and sprengeri require heavy loam, well enriched with manure. The potting soil should contain one-fourth manure by volume, with a four-inch potful of superphosphate to the bushel. After the first shift, additional food should be added to the potting soil in the form of a complete fertilizer. Liquid applications of urea or a 15-30-15, produce thick, bushy plants with long fronds. In a number of tests, horn shavings, superphosphate and complete fertilizers have proven far superior to manure alone or with bonemeal added. Nitrogen is needed to produce green, heavy foliage, and for this purpose the commercial fertilizers, high in nitrogen,



Asparagus

Urea Check Superphosphate

serve very adequately. To force the plants into flower and subsequent seed production, feeding should be reduced and the plants allowed to become potbound.

Azaleas

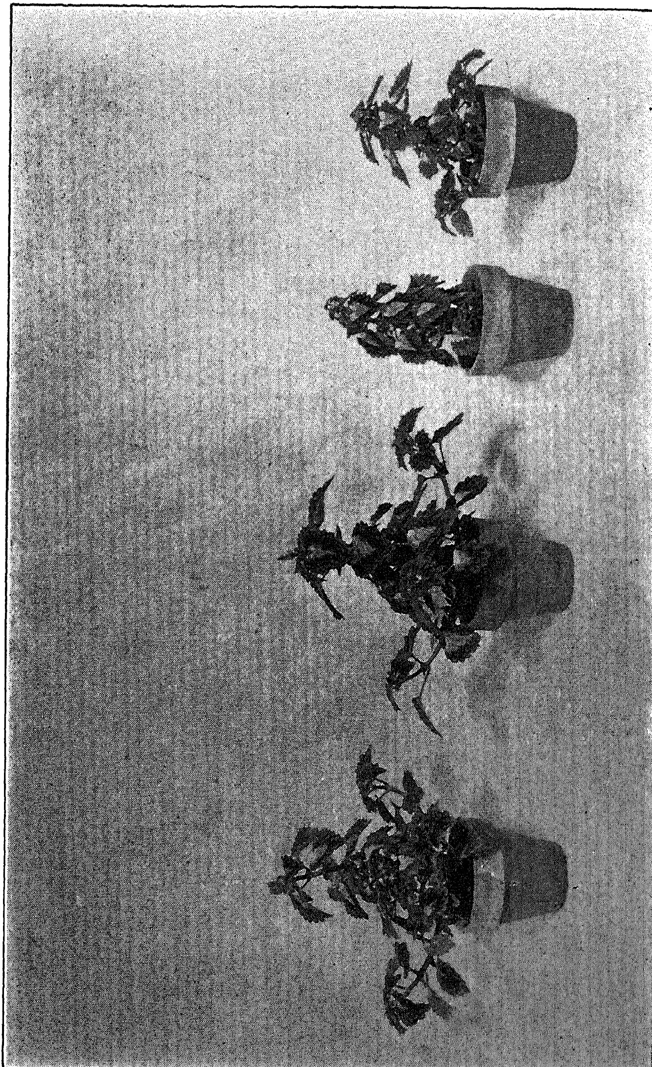
Azaleas are acid-tolerant and prefer soil without any lime. A turfy loam mixed with peat or leafmold, with a four-inch potful of 4-12-4 fertilizer added to each bushel of soil, produces satisfactory plants. To insure proper acidity during the period of growth, a mulch of peat should be placed in each pot a month before the plants are due to bloom. In addition to giving the desired degree of acidity, the material also furnishes nitrogen. At the time of potting, proper acidity may be secured by the addition of a three-inch potful of aluminum sulphate to every bushel of soil. The material acts as an acidifier. Lime in any form should not be used.

Bedding Plants

Taken as a whole, the requirements for such plants as Coleus, Alternanthera, Iresene and others are simple. A light, sandy loam, with one-fourth manure or leafmold, will grow them in a satisfactory manner for the short season of development before sale. If specimen plants of Coleus are desired, nitrogenous materials, such as urea or ammonium sulphate should be applied in liquid form. Geraniums are often sold as specimens for Mother's Day or Memorial Day. As such they require greater care in feeding than is sually afforded them. The usual practice of potting into four-inch pots, using any kind of soil with an addition of bonemeal, is very unsatisfactory. Large plants in six-inch pots may be easily grown if feeding is started in late March or early April. Numerous tests, experimentally as well as upon a commercial scale, have proven that the addition of such complete fertilizers

Geraniums

4-12-4 Check Horn Shavings



Coleus

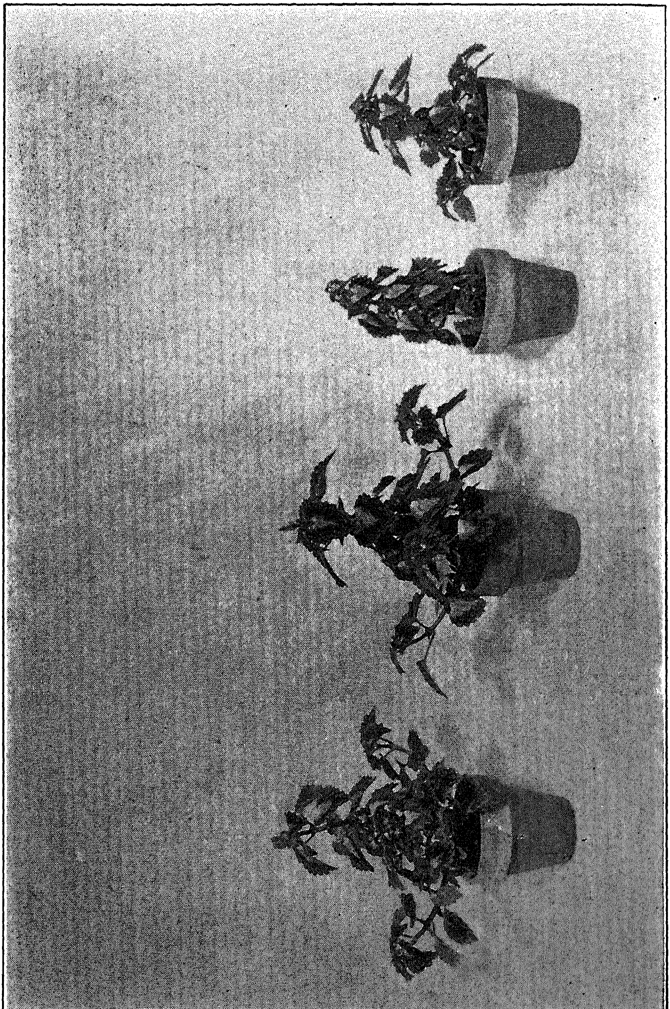
as 4-12-4 to the soil in themselves produce large specimens full of bloom, either for Mother's Day or for Memorial Day. The addition of superphosphate at the time of potting and later applications of liquid urea were next in effectiveness, followed by ammonium sulphate in liquid form, urea in liquid form, 15-30-15 and horn shavings. In general, nitrogenous materials used alone increased growth but checked flowering, but complete fertilizers or the addition of superphosphate at the time of potting, followed by nitrogenous applications, resulted very favorably from every standpoint. Bonemeal alone is not satisfactory, while sheep manure is undesirable.

Begonias

All classes of Begonia are partial to light, sandy loams to which leafmold, well decomposed manure or peat have been added in the ratio of three of soil to one of other materials. The Melior type at the last potting should be placed in soil to which a commercial fertilizer has been added. A 4-12-4 will be suitable. The same should be used for the Semperflorens type, which includes Gloire de Chatelaine, Vernon, Pride of Newcastle, and others. Tuberous Begonias favor even greater amounts of leafmold or peat than the other two mentioned. The Rex and the Winter-flowering, shrubby types need less shifting from pot to pot. For these liquid applications of urea, ammonium sulphate or calcium nitrate will be necessary once every three or four weeks. Superphosphate added to the soil at the time of potting will induce earlier and freer flowering.

Bulbs

Although fertilization of various bulbous plants is rarely considered once they have been potted in a good, rich soil, a much higher grade of flowers will be secured



Coleus

if liquid nitrogenous applications are made as soon as the pots are brought in for forcing. Liquid manures, urea or calcium nitrate are particularly desirable for this purpose. With tulips and hyacinths appreciably better results will be secured by such treatment. Narcissi may be increased in size but are likely to turn greenish-yellow if too much nitrogen is added. Lilies should receive several applications of a complete fertilizer after the stalks are one foot high. Since they are usually grown in small pots, the bulbs themselves take so much space that they leave little room for soil containing nourishment. Larger blooms and better foliage result from feeding. The use of bonemeal is not advised as a top dressing, since its action is slow and no effect will be produced in time to be of any value. Horn shavings give off nitrogen quickly. The same holds true of dried blood. These two materials may be used safely if other nitrogenous materials are not available.

Calceolarias

A light, sandy compost, made in the usual manner, is the best soil for Calceolaria. Leafmold is sometimes advocated in the mixture, but unless the soil is heavy its addition is unnecessary and often detrimental. One specialist recommends the following: "When the plants are given their final shift, one six-inch pot of granulated charcoal, one four-inch pot of bonemeal, and one four-inch pot of soot should be added to the soil, sifted twice, leaving the compost in small lumps." In this recommendation, charcoal is used both as drainage and sweetener of the soil. It does very well. The use of bonemeal is to be questioned. In its place superphosphate will become available more quickly, and it is phosphorus that is needed and not nitrogen. The latter is being provided in very small quantities from the soot recommended. Experiments

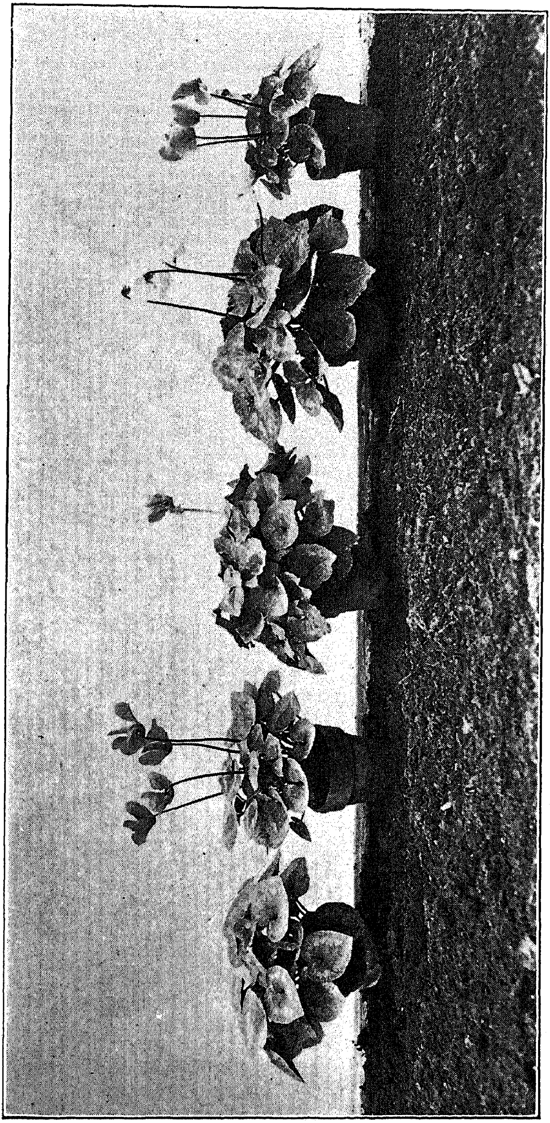
show that both of these substances can be supplied at once through the use of a complete fertilizer. In a number of tests where complete fertilizers were used in comparison with ordinary compost, compost and bonemeal, compost, bonemeal and soot, considerable increase in growth and flowering was secured through the use of 15-30-15, 20-30-20 in liquid form once in two weeks, and 4-12-4 added in dry form. The increase in growth due to bonemeal and soot applications was wholly negligible.

Chrysanthemums

The soil and fertilizers advocated for Chrysanthemums in benches or beds should be used for pot plants as well. The application of additional food requires considerable care. If the pots are filled with roots and drainage is good, nitrogenous fertilizers should be applied at regular intervals, usually once in two weeks. This procedure helps retain the foliage which often is lost at the base. However, more pinching will be found necessary because of the ranker growth attained. Liquid manure, sulphate of ammonia, urea or dried blood are the most satisfactory materials. Complete fertilizers in liquid form should be applied after the buds begin to form, but not after color is showing. Feeding continued after buds show color fades pinks and reds and causes them to look muddy.

Cinerarias

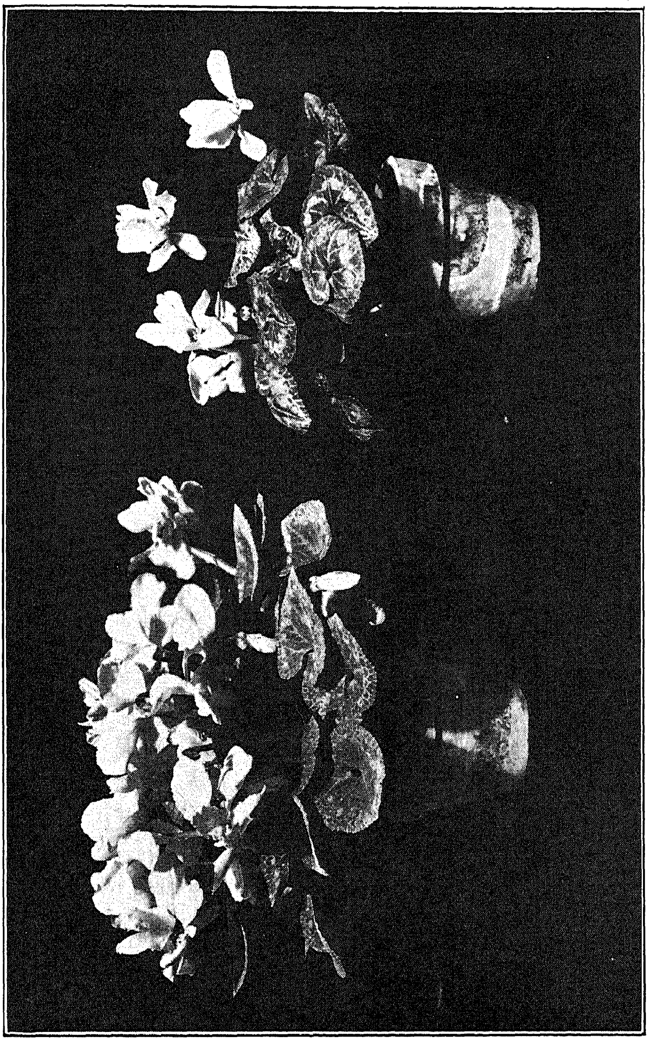
Light loam, porous and coarse, is ideal for Cinerarias. One-fourth well rotted manure added to the soil at the time of potting, together with a four-inch potful of superphosphate or 4-12-4 fertilizer, will supply sufficient nutrients so that further feeding will not be needed. Drainage of the soil is one of the prime essentials. Cinerarias are quick growing plants and overfeeding may become injurious. Nitrogenous fertilizers tend to produce extremely heavy succulent foliage and delay flowering.



Cyclamens
Left to Right: Urea; Superphosphate; 20-30-20; Superphosphate and Urea; Check

Cyclamens

The usual potting soil for Cyclamens consists of one-fourth manure and leafmold added to a sandy loam soil. Bonemeal, sheep manure and lime have formed the basis of fertilization in the development of the plant from one stage to the next. Charcoal has been used to keep the soil "sweet." Commercial fertilizers have been taboo, although an occasional grower uses liquid cow manure. However, recent data indicate that the cumbersome method of shifting in the last stages from one pot to another can be eliminated through the use of commercial fertilizers. Fine plants may be secured by this treatment in six-inch pots instead of eight-inch. Inclusion of one-fifth peat in the potting compost used at all stages should be tried. When the plants reach five-inch pots regular feeding should start. The addition of superphosphate to the potting soil is desirable. This material alone results in considerable improvement over compost alone. The best results are secured through the use of superphosphate and regular feeding with urea, applied once in two weeks, always when the soil is moist, at the rate of one ounce to ten gallons of water. This feeding may be started from four inch pots on. Complete fertilizers have also been found very satisfactory. The 20-30-20, 15-30-15 and 4-12-4 gave results which were only slightly inferior to the combination of superphosphate and urea. Nitrogenous materials alone tend to produce too much foliage in proportion to the flowers. By means of this feeding, plants were obtained, in five-inch pots, which were as good as many seen in eight-inch containers. The notion that such plants would not keep on growing and flowering after passing into the hands of the ultimate consumer is erroneous. The profuseness of bloom maintained for weeks after all feeding stopped testified that, on the contrary, this treatment is beneficial. Continued feeding



Cyclamens

Urea and Superphosphate Check

stores in the soil nutrients which are gradually delivered to the plant for a long period after all feeding has stopped. Drainage is one of the essentials in cyclamen culture, and no better way has been found than through the use of the new four-hole Cyclamen pot.

Ferns

Any good, fibrous loam including one-fourth well rotted manure or the same amount of leafmold suffices for ferns. When the plants are well rooted, nitrogenous applications are very desirable, as liquid manure, dried blood and, particularly, urea. Superphosphate should be added to the potting soil. Horn shavings are good and bonemeal answers the purpose in a lesser degree. The substitute of peat for leafmold increases the porosity of the soil and provides an additional source of rather quickly available nitrogen. It has been found that rich composts, combined with extremely firm potting, reduce the tendency of such ferns as Nephrolepis whitmani and elegantissima to revert back to the Boston type.

Gloxinias

Gloxinia is similar in its requirements to the tuberous Begonia.

Fuchsias

Fuchsia is best suited by a soil composed of two parts loam, one part well rotted manure and one part leafmold. Addition of superphosphate at the time of planting should be made. Further feeding with a complete fertilizer should come after the plants have been shifted to their final pots and have filled the pot with roots.

House Plants

Even when other conditions are ideal, good soil is necessary for the growth of good plants. Plants adapt

themselves readily to various soils provided the nutrient elements are present in available form. A good soil mixture is composed of one-half garden loam, one-quarter sand, and one-quarter leafmold or well rotted manure. The loam may be any soil containing considerable clay and some decayed organic matter. Sand is necessary to provide drainage and to prevent packing and caking. Leafmold and manure supply in part the nutrients in readily available form. The addition of six level teaspoons of bonemeal to each peck of potting soil when it is mixed will be found beneficial. Usually, the plants bought from a reliable florist are potted in a mixture which requires no immediate addition of fertilizer; later, when the supply of the available nutrient material becomes exhausted, fertilizers in concentrated form may be obtained and these be applied in accordance with the directions given. These applications should be given about once in two weeks during Spring and Fall, but during the dark Winter days the interval should be lengthened to once a month. At this time many of the foliage plants are enjoying a period of dormancy or "rest" and should not be fed at all.

Hydrangeas

Hydrangeas are strong feeders and require a rich, fairly heavy loam with an abundance of humus, which may be supplied by the addition of one-fourth manure. Good drainage is essential. It has been found that Hydrangeas are benefited particularly by the application of phosphate and potassic materials. Because of that, superphosphate should be added to the soil at potting, and later one or two doses of liquid potassium sulphate applied to the pots. Dissolve one ounce to one gallon of water before applying. Complete fertilizers with a low percentage of nitrogen are beneficial. Nitrogenous materials alone cause imperfect green flowers and sometimes blindness.

As indicated in a previous chapter, the addition of alum or aluminum sulphate (one part to 200 of soil) will change the color of flowers to blue.

Palms

Palms do best in pots which are comparatively small and require a fairly heavy, fibrous loam soil with an addition of bonemeal and manure. Bonemeal is preferred in this case because of its slow action, which is spread over a long period of time. Since palms are rarely potted oftener than once a year, the mixture recommended is suitable. Under ideal cultural conditions in the greenhouse, additions of liquid manure or urea hasten growth and development. One application per month is sufficient.

Pelargoniums

Pelargoniums require fibrous, coarse loam with a liberal mixture of humus. Large specimens full of bloom may be produced for Mother's Day or Easter by the use of commercial fertilizers. The potting of soil at the last shift should contain a complete fertilizer of medium concentration (4-12-4). This will have been consumed by the plant in two or three weeks, when an additional application should be made. Experimental data show that this material is the best of numerous compounds tried. The other fertilizers, of higher concentration, were far superior to the compost alone, but not quite as good as 4-12-4.

Poinsettias

These are partial to heavy loams. A mixture of two-thirds fibrous, clay loam and one-third well rotted manure suits them perfectly. At the last shift, an addition of superphosphate should be made. If the foliage is not luxuriant and looks yellow, one or two applications of a

complete fertilizer of medium concentration may be made. The yellowing and dropping of the foliage may be due to other causes, such as drop in temperature, careless potting, insects, but if the foliage remains on the plant and is sickly looking, it is reasonable to assume that food is lacking. Strong nitrogenous fertilizers should be avoided to prevent succulence of growth and poor keeping qualities.

Primroses

Primroses thrive in light, sandy soil to which one-fourth leafmold has been added. At the final shift add superphosphate to the potting soil and later an occasional top dressing of a complete commercial fertilizer (4-12-4) once every four weeks. In the Primrose, light green foliage, with a yellow rim, is often an indication of lack of nitrogen. The same condition will arise, however, from overwatering or overfumigation with tobacco or cyanogen.

Roses in Pots

Roses in pots require similar condition of fertilization and soils to those grown in benches. If the plants have been properly grown out of doors previous to being dug for forcing, no trouble will be experienced in bringing them to profusion of bloom at the time desired. Whether grown in the coldframe or out in the field, the preparatory treatment should be based on judicious feeding. After potting in medium heavy, well drained soil composted with one-fourth well rotted cow manure and superphosphate, no further feeding will be needed for several weeks. One month before flower buds appear, a top dressing of complete fertilizer should be given. A 4-12-4 or 6-8-6 will give good results. This should be followed with another application when the buds show, which usually is one month before the plants are wanted for sale.

Tropical Foliage Plants

Tropical foliage plants, such as Dracaena, Pandanus, Rubber Plant and others of the same nature, prefer medium heavy loam, not too finely broken up and with an addition of one-fourth well rotted manure or leafmold. They remain in small pots for long periods of time and thus are benefited by top dressings of peat or commercial fertilizers. Feeding should be practiced only during the growing seasons and not when they are partly dormant, which occurs in the dark, dull days of Winter.

Vinca

This is one of the most popular of the vines used in porch boxes and urns. It requires a good, rich soil. Light loam is best for the initial potting, and it may be made richer by the addition of manure and commercial fertilizers (4-12-4) when shifted into four-inch pots. If the growth is slow, added doses of liquid manure, urea or calcium nitrate will be found beneficial. These should not be applied before Spring.

RECOMMENDATIONS

In all cases where definite recommendations have been made, no account was taken of the individual soils of the grower. Soils of similar texture may contain widely different percentages of available plant nutrients. It is necessary, therefore, to make allowances and to adopt practices in accordance with the available soils. The use of old standbys may be perfectly good, but in the majority of cases where a grower makes definite recommendations he may not have attempted the trial of anything else, and in some instances has not even compared treatments. Therefore, if any treatments and recommendations made here seem radical, a trial should be made before they are condemned.

CHAPTER VI

GREENHOUSE VEGETABLE CROPS

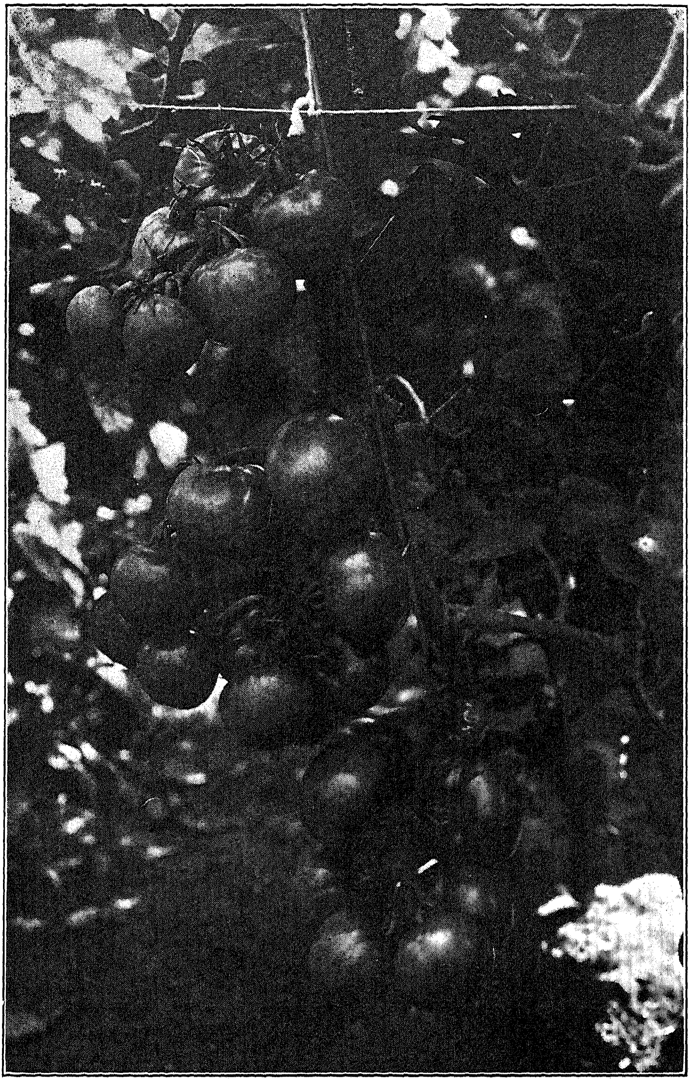
TOMATO

Soils

SOILS for greenhouse Tomatoes should have high fertility combined with looseness and openness of texture. Well drained, sandy loams are usually considered the best. This type of soil is generally well suited to the application of fertilizer, is not easily injured by tilling operations, and provides good aeration.

General Considerations

The Tomato plant is very sensitive to certain environmental conditions. The amount of light and nitrogen available frequently determines the character of growth and setting of the fruit. Fall crops are started under better light conditions than Spring crops. Plants receiving maximum sunlight can utilize more nitrogen than those receiving minimum sunlight. Excessive quantities of nitrogen, applied either in the form of fresh horse manure or commercial fertilizer, when the days are comparatively short (January to March), are likely to produce extremely vegetative and non-fruitful plants. The failure of the Spring crop to set the first cluster, a frequent occurence in Tomato forcing houses, is often attributed to excessive nitrogen in the soil and to restricted light. On the other hand, the same amount of nitrogen applied



Grand Rapids Forcing Tomato
Superphosphate and Manure in Soil

in the soil during August and September may induce excellent setting of the fruit without any harmful reduction in vegetative vigor. In other words, setting of fruit is associated with vegetative vigor. If conditions are such that vegetative growth is rapid, the foods manufactured within the plants are used entirely for production of stems and leaves only. If, on the other hand, vegetative growth is less rapid, the foods manufactured can be utilized not only for the production of stems and leaves, but also for the setting and maturation of fruit. This does not mean that nitrogen and the amount of light available are the only factors affecting vegetative growth and fruit setting. High temperatures, low humidity of the air, variation in moisture or in other fertilizer ingredients have been known to markedly influence fruit setting. It does not mean, however, that applications in kind and amount of fertilizer should vary from season to season within the year and with the maturity of the plants.

Spring Crops

When the plants are first set out, nitrogen should be used sparingly. Excess of nitrogen favors the development of extreme vigorous growth and sterile pollen and susceptibility to certain diseases. In case the preceding crop has received an application of well rotted barnyard manure, an application of superphosphate or a complete mixture high in phosphorus should produce very satisfactory results. The ratio of phosphoric acid to potash should be three to one on comparatively new soils, and four to one on soils which have been heavily manured for a long period of years. If the plants are too vigorous, and the first or second cluster fails to set fruit abundantly, an additional supply of superphosphate applied at the rate of 20 pounds per 100 square feet may induce fruit setting on succeeding clusters. To maintain vigor and

productivity, a good plan is to apply a complete mixture fairly high in superphosphate (4-12-4); or 4-16-4 broadcast at the rate of one to two pounds per 100 square feet of bed space when the fourth or fifth cluster has set: This should be worked very thoroughly into the surface of the soil. Succeeding applications should be made at intervals of two or three weeks at one to two pounds per 100 square feet of bed space, depending upon the vigor of the plants. Applications of manure alone fail to produce as great net returns as manure supplemented with a well balanced commercial fertilizer.

Fall Crops

For fertilizing the Fall crop, manure for supplying the nitrogen may be spaded in when the bed is being prepared. Instead of incorporating the manure in the soil, growers often use this material as a mulch to insure a uniform supply of moisture in the soil to aid in preventing blossom end rot. In addition to the manure, a complete fertilizer, high in superphosphate (4-12-4 or 4-16-4) should be applied either as a top dressing or when the soil is being prepared. Chicken and sheep manure, if applied as a mulch, should be used in very small quantities. When the fruit begins to ripen, a commercial mixture such as 4-12-4 or 4-16-4 applied broadcast and worked into the upper inch of soil at the rate of 20 pounds per 1000 square feet at intervals of two weeks should produce satisfactory crops under average conditions.

CUCUMBERS

Soils

Cucumbers grow best on well drained soils of rather coarse texture. These soils permit extensive root development and excellent aeration. Good drainage facilities are essential. The roots of the Cucumber plant are very sensitive to waterlogging.

General Considerations

Growth must be continuous and rapid. A fair indication of lack of vigor is the production of large numbers of female blossoms, yellowing of the lower leaves and young fruits and development of large percentages of nubbins. In case nutrients are lacking in the soil when the plants are producing heavily, the newly pollinated blossoms become yellow and die. Uniform watering, combined with judicious applications of commercial mixtures, assist in maintaining vigor and productiveness. Obviously, commercial mixtures or manure mulches can be applied most advantageously when the plants are beginning to produce heavily. For this reason mulching may be highly desirable when the vines have attained a height of about three feet.

Spring Crops

Unless the fertility of the soil is depleted manure need not be applied to the Spring crop. When the soil is being prepared, superphosphate and potassium (ratio of two to one) should be incorporated at the rate of five pounds per 100 square feet. In most cases, nitrogen should not be applied until first fruits have begun to develop. Too much nitrogen in the soil when the crop is planted tends to produce a large amount of undersized fruit of poor quality. Planting the crop somewhat later in April or May permits the utilization of more nitrogen; in this case the nitrogen may be applied with phosphorus and potassium in the form of a complete mixture at the time of soil preparation. Succeeding applications of a complete mixture should be made at intervals of two or three weeks, depending on the vigor of the plants. Mixtures high in superphosphate such as 4-12-4 or 4-16-4 broadcasted at the rate of two to three pounds per 100 square feet are recommended.

Fall Crops

Plants can utilize more nitrogen at this time of the year because of excellent light conditions. Usually too little, rather than too much, fertilizer is applied. Yellowing of lower leaves and development of large quantities of poorly shaped fruits indicate a lack of nitrogen. In general, nitrogen deficiency in the soil may be made up by applying sodium nitrate or ammonium sulphate at the rate of one pound per 100 square feet of bed space. When the plants begin to bear heavily, commercial fertilizers, applied at intervals of two or three weeks, generally produce satisfactory crops. In many cases, barnyard, chicken or sheep manure applied as a mulch when the plants begin to produce heavily may be highly desirable, especially on well drained soils. A mixture high in superphosphate (4-12-4 or 4-16-4) should be used. The rate of application should vary from two to four pounds per 100 square feet of bed space, the amount depending on the type of soil, vigor of the plants and previous fertilization.

LETTUCE

Soils

Lettuce is grown most successfully in the greenhouse, on rich, loamy soils. Since these soils contain considerable sand and organic matter, they permit good aeration and possess high water-holding capacity. Good drainage is essential.

Fertilization

On highly fertile soils which have produced satisfactroy crops of Lettuce for a period of years, moderate applications of manure (10 to 16 tons per acre), plus the use of a complete mixture (3-12-4 or 4-16-4), applied at the rate of one to two pounds per 10 square feet of bed, is

likely to produce the greatest net returns. If large applications of manure are made (more than 20 tons per acre), 40 to 50 pounds of superphosphate should be applied for every ton of manure used. In case manure is not used, complete fertilizers high in phosphorus (3-12-4, 4-12-4 or 4-16-4) should produce greater yields than the application of any single ingredient or any combination of nitrogen and potassium or nitrogen and phosphorus.

On sandy soils deficient in organic matter, large applications of manure should be made (20 to 30 tons per acre) until the humus content of the soil has been built up. This material should be supplemented with commercial fertilizers.

If for any reason plants fail to grow immediately after they are set in the permanent bed, a condition frequently occurring immediately after sterilization of soil with steam, an application of nitrate of soda (one-half to one pound to 100 square feet) is advised.

Unless the soil is very acid and contains large quantities of aluminum, lime should never be applied in large quantities to lettuce crops. On soils producing satisfactory crops, annual applications of lime of more than two pounds per 100 square feet should be avoided. Lesser quantities applied annually should produce better crops for a given period of years. For the most satisfactory growth the soil reaction should be *slightly acid.* In most cases, especially on highly fertile soils, this condition may be maintained by the usual applications of fertilizers high in phosphorus (3-12-4, 4-12-4 or 4-16-4). There is some indication that more lime is needed for the Cucumber-Lettuce system of cropping than for the Tomato-Lettuce system.

RADISH

Radishes produce the best roots on loose, friable, sandy loams. This type of soil permits the proper develop-

ment of the roots and decreases the possibility of producing excessive top growth.

Fertilizers

Though in the greenhouse applications of commercial fertilizers are seldom made directly to the Radish crop, beds continually growing Radishes throughout the Winter months should receive some. Mixtures fairly high in potash, as 5-8-7, are recommended. For one or even two crops of Radishes, the fertilizers applied to other crops (Tomatoes, Cucumbers or Lettuce) generally suffice. On very light, sandy soils, however, light applications of well decomposed barnyard manure are particularly helpful. If for any reason the nitrogen supply in the soil is so abundant as to produce excessive top growth at the expense of desirable root development, an application of superphosphate (not bonemeal), one pound per 100 square feet, is advised. On the average greenhouse soil, the residue of the fertilizers recommended for Cucumbers, Tomatoes or Lettuce should produce satisfactory crops of Radish. Since the Radish is tolerant of acidity in soils, lime is not needed.

USE OF LIME ON VEGETABLE GREENHOUSE CROPS

The fact that Tomatoes and Radishes are rather tolerant to soil acidity, and Cucumbers and Lettuce less so, makes outlining a program for use of lime in greenhouses very difficult. Furthermore, the wide variation in the chemical composition of different greenhouse soils, and the diverse systems of soil management employed by growers, decidedly limit the possibility of making general recommednations. In some sections the majority of successful growers use very little lime, if at all. In other sections most growers obtain the best results from annual applications.

In general, the amount of lime necessary depends on soil type, the kind and amount of fertilizers used, and the systems of cropping.

Light sandy soils are likely to require more lime than heavy soils. Particular attention should be given to soils containing active aluminum. This element is detrimental to plant growth, and applications of lime will render it harmless. Active aluminum is found in greenhouse sections in the Eastern States to a greater degree than in those of the Middle West.

The kind and amount of fertilizer used determines the amount of lime required in any given establishment. Furthermore, changes in the ingredients of fertilizers may or may not require lime. The substitution of 16 to 20 per cent superphosphate for 40 to 44 per cent superphosphate requires additional lime. Certain nitrogenous fertilizers, such as ammonium sulphate or leunasaltpetre, become oxidized in the soil and yield sulphuric and nitric acid. Others, such as nitrate of soda or nitrate of calcium, yield an alkaline reaction, while others, again, such as urea, produce neither acid nor alkaline. Certainly the long continued use of fertilizers yielding acids in the soil increases soil acidity and makes the use of lime imperative. On the other hand, using fertilizers having an alkaline reaction decreases soil acidity and may render the soil too highly alkaline for best results. The lower cost of some of the acid producing fertilizers, plus the additional use of lime, may justify their use. Superphosphate is considered a good conditioner as far as soil reaction is concerned. It will prevent the soil from becoming too acid on the one hand and not entirely too alkaline on the other. A slight excess of acid will be rendered harmless by applying liberal applications of superphosphate.

Authorities agree that soil should be slightly acid for the satisfactory growth of most greenhouse crops. Con-

sequently, growers should endeavor to maintain this condition. Before applications of lime are made, lime requirements of any particular crop should be determined. The Soiltex apparatus furnishes a quick and accurate means for making such determinations. Except when the soil is very acid or is badly puddled, lime is not needed. Even in cases where the application of lime is considered justifiable, only small to moderately large quantities should be used. Often a slight excess of acidity may be rendered harmless by using fertilizers high in superphosphate.

For the Tomato-Lettuce crop system where manure is applied annually and superphosphate used rather liberally, very little lime is needed, if at all. Annual applications should not exceed 20 pounds per 1000 square feet. For the Cucumber-Lettuce system grown on the same type of soil and similarly fertilized, more lime may be necessary.

CHAPTER VII

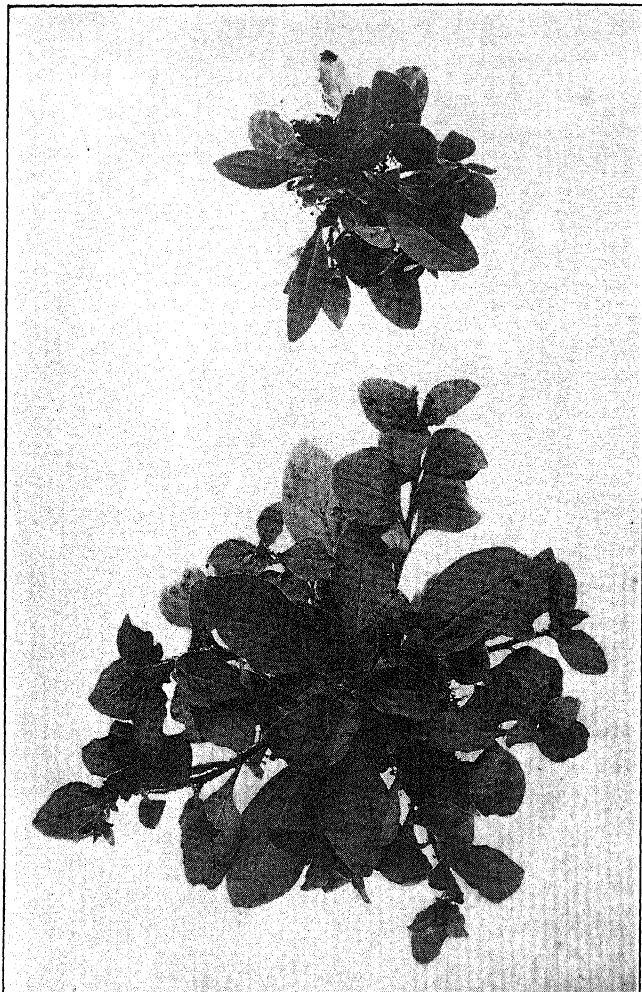
OUTDOOR ORNAMENTAL CROPS

Annuals

Thorough preparation of the soil is essential; this may be done either in the Fall or in the Spring. In small gardens the soil should be dug to a depth of 18 inches to two feet; this usually lessens the need of constant watering during the period of growth. A light loam is suitable to the majority of the annual flowering plants. A dressing of two inches of well decayed manure should be spaded in; leafmold may be used for the same purpose. Many annuals are partial to limed soil. The more common of these are Alyssum, Candytuft, Carnation, Impatiens, Mignonette, Nasturtium, Pansy, Phlox, Poppy, Sweet Pea and Zinnia. Those but slightly affected by acidity include Ageratum, Asters, Calendula, Gaillardia, Lobelia, Petunia and Salvia. Some tolerate or prefer acidity, such as Castor Bean, Calliopsis, Lupine, Marigold, Nicotiana and Verbena. When needed, lime should be applied in the Spring at the rate of one pound to 25 square feet of ground once in two or three years.

The following annuals will grow fairly well even in the poorest of soils: Alyssum, Balsam, Bachelor Button, California Poppy, Calliopsis, Godetia, Josephs-coat (Amarathus), Nigella, Nasturtium and Portulaca.

After planting, a mulch of peat has been found advantageous in many cases. Tests indicate that a large majority of annuals are benefited by this treatment. Peat

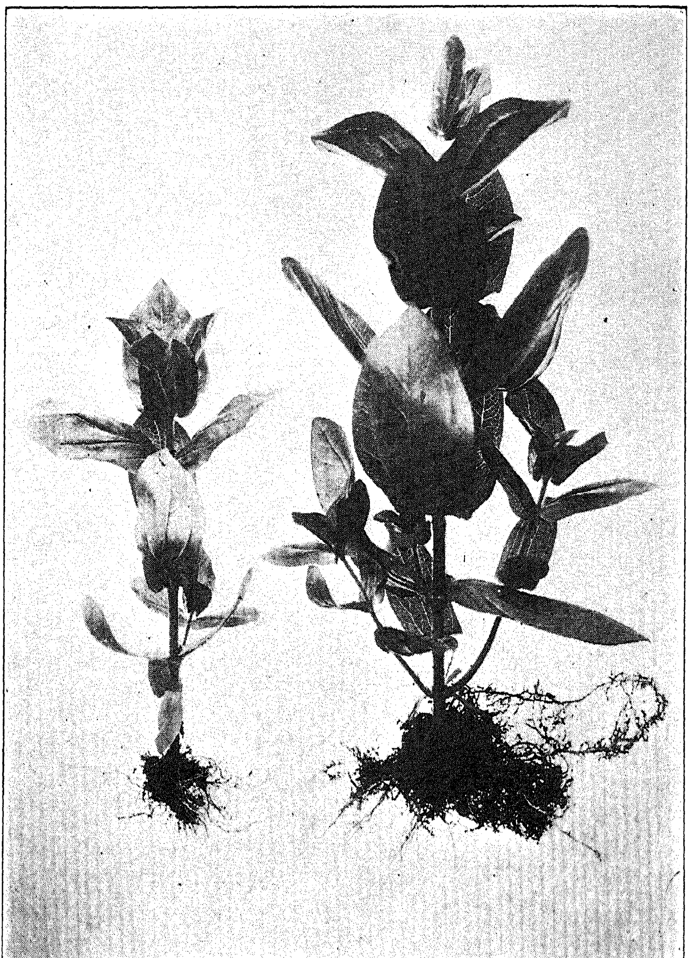


Peat Mulch **Petunias** **Soil**

mulch keeps the soil cool and furnishes nitrogen, particularly if manure has been incorporated previously to add the needed bacteria which act upon the peat and release the nitrogen. Some annuals (Mesembryanthemum, Portulaca, Poppy, etc.), prefer high temperatures and require no mulch. Further applications of fertilizers depend upon the nature of the food supply. If vigorous growth obtains, no further additions are needed. Stunted growth, yellowing of foliage and failure to bloom, not due to diseased condition or attacks by insects, indicate the need of additional nutrients. The application of superphosphate at the time of planting may be found desirable. Early in July, and once again in August, a complete fertilizer mixture should be added in dry form, with care against getting the material on the foliage. Very fine results have been obtained through the use of 4-12-4 at the rate of two pounds to every 100 square feet, or 15-30-15 at one-half the rate. The latter material may be applied in liquid form. When plants are grown on a larger scale, the same principles of fertilization apply.

Asters

Early Asters have a short growing season and conditions should be made as favorable as possible for their rapid growth. Since planting is done early, no fresh manure should be applied in the Spring; Fall applications of well rotted manure are preferable. The addition of superphosphate should be made in the Spring or, just before planting, a complete commercial fertilizer may be applied at the rate of 600 pounds to the acre (roughly, one pound per 75 square feet). A 4-8-4 mixture will be acceptable. Quickly soluble nitrogenous fertilizers should be avoided, because of the possibility of inducing those diseases which associate with succulent growth. Lime is beneficial and may be used liberally at planting and dusted about the



Zinnias

Soil **Peat Mulch**

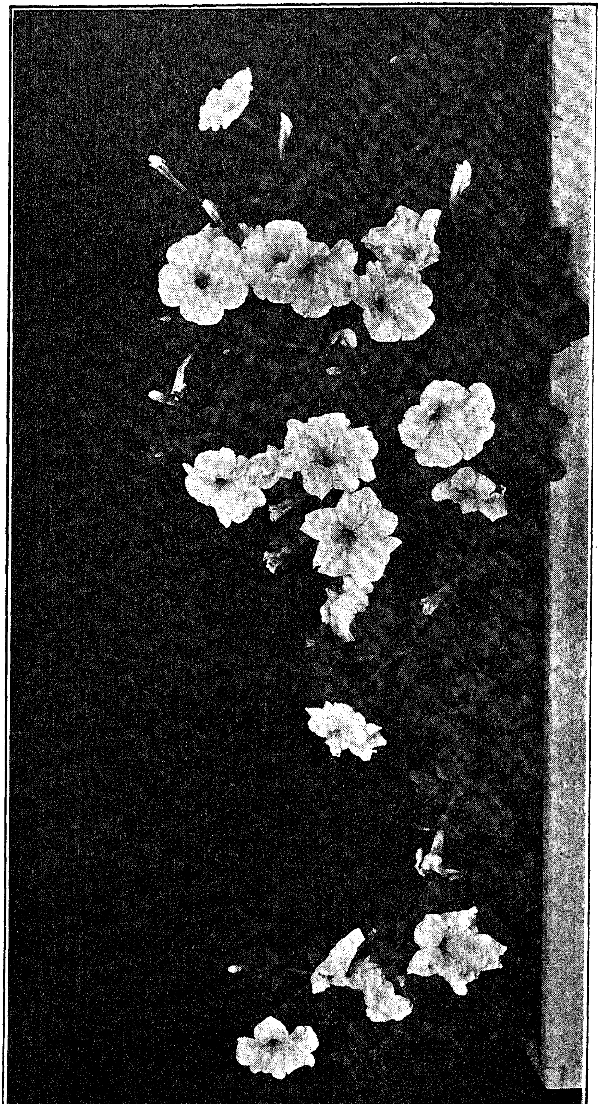
plants during their growth. Peat moss, applied as a mulch, has also been found beneficial.

The soil for late Asters should be prepared early in the Spring and kept fallow until planting time. Frequent cultivation and stirring of this land puts it in the best physical condition, with many of the weeds eliminated and the humus incorporated thoroughly. Because of the longer period required for maturity, the late Asters do not require quite as rich soil as the early, but in order to secure the highest quality and the greatest production, one application of commercial fertilizer should be made about one month after planting. Experimental results indicate the need of fertilizer high in phosphorus and potash.

Sweet Peas

A well drained, medium loam will grow Sweet Peas, but to produce long stemmed, marketable blooms special preparation is necessary. Because of the deep rooting propensities of the crop, the soil for Sweet Peas must be deep; it should be trenched or turned to a depth of 18 inches in the Fall. The subsoil (if poor) should be removed and replaced by a compost of sod and manure, but if this is not available, any good garden loam serves the purpose. Manure, leafmold or straw should be placed at the bottom of the trench to a depth of four inches. At the same time, lime and bonemeal should be applied, the amount of lime depending on the acidity or alkalinity of the soil, which may be determined by the use of a Soiltex oufit. Since Sweet Peas dislike acidity, acid soil is detrimental to growth no matter how fertile it may be. The bonemeal should be added at the rate of five pounds to every 100 feet of trench.

In the Spring, after the first flowers have been picked, four pounds of 4-12-4 or 6-8-6 fertilizer should be applied



Check **Petunias** Urea

to every 100 feet of row. Later, when the stems are shorter, during the hot days of the Summer, nitrogen should be applied in liquid form. Urea or calcium nitrate, alternated with liquid animal manure, applied once a week, answers the purpose. Potassium nitrate at the rate of one ounce to five gallons of water may be substituted for the other nitrogenous materials.

Strawflowers

Strawflowers and Chinese Lantern Plant (Physalis) are benefited by a 0-10-10 fertilizer applied at the time of planting at the rate of 1000 pounds to the acre (approximately, 1 pound to 50 square feet).

Herbaceous Perennials

Preparation of the soil for herbaceous perennials does not differ essentially from that for the annuals, except that it should be even more thorough, since the plants remain in the ground for a number of years. Preparation to considerable depth is essential. The majority of the plants prefer an occasional application of lime, though a few, including Baptisia, Coreopsis, Lupinus, Platycodon and Silene, are acid-tolerant.

To maintain the proper physical condition of the soil, the Winter mulch of manure, leaves or peat should be worked into the soil in the Spring. Applications of complete fertilizers in dry form during the season of growth are beneficial. The use of liquid fertilizers should be limited to light doses once in two weeks, not later than August 1. Otherwise, the succulent growth which they produce would leave the plants in an immature condition for Winter, with subsequent injury. Superphosphate should be added every Spring. Bonemeal may also be used, but no results should be expected from it for many weeks.

Hardy Ferns

The soil for growing hardy ferns should approximate the medium in which they grow in their native state. Leafmold, well rotted manure and peat should form the bulk of the soil. To secure good drainage, which is essential, it may be necessary to raise the beds above the level of the adjacent ground.

Irises

Although Irises will grow in any kind of soil, a medium heavy loam is best. Even heavy clay will produce good plants and excellent bloom if it is well drained and limed. In heavy soil, plantings require a longer period for becoming established, but satisfactory growth is maintained for a longer period without division. For the commercial production of rhizomes, sandy soils should be utilized.

The best method of soil preparation is to incorporate manures or green crops the season before the Iris is planted. Bone or superphosphate should be added to the soil before the rhizomes are set. Additional commercial fertilizers should be applied, once during the period of growth before flowering in the Spring, and once again after blooming. The first application may be of nitrogenous nature, in the form of liquid urea or calcium nitrate. The second application should be composed of phosphorus and potash. A 2-10-10 mixture is best for this purpose.

Peonies

Peony flowers are produced best in a rather heavy loam with a clay subsoil, provided that it is not impervious to water and drains well. For the development of the roots and propagating purposes, a light soil should be utilized. Very deep preparation is necessary, since the roots are usually planted so that the crown is fully two or three inches below the surface of the soil. Well rotted

manure should be incorporated with the soil deeply enough so that it does not come in contact with the roots. Lime should be applied at the rate of five pounds to 100 square feet. Bonemeal or superphosphate, as well as potash, should be added to the soil before planting. A 2-10-10 mixture is excellent for Peonies. It should be applied once after blooming in the Summer and may also be used very early in the Spring as soon as growth shows above ground. Every Fall, bonemeal should be applied or, in the Spring, superphosphate should be added. The latter will secure earliness of bloom, which is often essential in commercial production.

If a mulch of manure is placed over the plants in the Fall, it should be incorporated into the soil in the Spring. Beginning when the buds form, applications of a nitrogenous fertilizer once a week will increase the size of flowers; for this purpose, urea or ammonium sulphate gives satisfactory results. Dried blood and tankage may be substituted for these.

Spring Flowering Bulbs

The major bulbous crops, such as Tulips, Narcissi and Hyacinths, as well as those of less importance (Ixia, Grape Hyacinth, Scilla, Crocus, etc.), do well on silt or sandy loams which are well drained. Soils which produce good crops of grain or vegetables may not be suitable for bulbs. which are essentially a Winter crop. Bulbs planted in the Fall and left over Winter have quite different requirements from the crops planted in the Spring after the soil has dried out sufficiently to be handled. The culture of bulbs should not be attempted in soils where water will not drain away readily to a depth of 20 to 24 inches.

The safest procedure in securing fertility is to apply fertilizers to the crop which precedes the bulbs. Manure

should be incorporated for the preceding crop, but superphosphate and potash may be used just before planting in the Fall. If it has been impossible to follow this practice, very fine well decomposed manure may be mixed thoroughly in the soil before planting. Fermenting particles in the soil often start basal rots which cause the young roots to decay and this decay extends to the base of the bulb.

If the soil is in good tilth and contains a sufficient amount of humus, commercial fertilizers should be applied during the second season of bulb development and, if the crop is grown for cut flowers only, every season. The application should be made early in the Spring and should consist of a complete commercial fertilizer, such as 2-10-10, high in phosphorus and potash, or a more balanced material like 4-12-4, applied at the rate of two pounds to 100 square feet or 1000 pounds to the acre. Because of its slow availability, bonemeal should be applied in the Fall.

Lilies

Lilies are benefited by deep soil preparation. Sandy loams are suited to the Madonna Lily, while clay loams are better for the Easter Lily, and peaty soils are preferable for the Regal Lily. In general, most of the Lilies do well upon soils which are well drained, deeply prepared and fertile. Manure of any kind should not come in direct contact with the bulbs, unless it is well decayed and properly incorporated with the soil. Bonemeal should be used in the Fall, while superphosphate and complete commercial mixtures may be added every season in the Spring. A 2-16-2 mixture has been found very useful.

Dahlias

Light loam soils are preferable to heavy loams and clays for Dahlias, although good results can be secured

with the latter types, providing there is proper drainage and sufficient humus. Heavy soils should receive manure in the Fall, and with the lighter types the application may be made in the Spring before planting. Like most root crops, Dahlias are benefited by additions of phosphorus and potash. For this purpose, bonemeal should be added in the Fall at the time of manuring or, in light soils, superphosphate in the Spring, using 2500 pounds to the acre or about five pounds to every 100 square feet. Nitrogenous fertilizers should be avoided, except in cases where deficiency of this element is indicated by yellowing of foliage and stunted growth. Overdoses of nitrogen result in succulent growth, poor keeping quality of the flowers and large tubers which rot in storage. After the tops have reached about one foot in growth during the Summer, a topdressing of commercial fertilizer should be applied at the rate of two or three ounces per plant. On lighter soils a 2-10-10 is desirable, while on heavier media a 2-10-6 is preferable. In very sandy soils, ammonium sulphate may be used in dry or liquid form. Urea or 15-30-15 are also good. To keep the soil cool, a mulch of well rotted manure or peat should be applied.

Gladiolus

A sandy loam, slightly acid in its reaction, is most suitable for the best development of Gladiolus. Heavier soils produce better quality of flowers and higher crowned corms, but decrease the number of cormlets formed. The type of soil utilized should vary with the purpose of the grower. Gladiolus can do without lime, but, if the soil supports the growth of sorrel, moss or sour grass, lime application is needed. A ton of lime to the acre, applied in the Fall, is enough to last for two or three years.

For best practice, the soil should be manured in the Fall, plowed and left rough. At this time liming may be

done and 1000 pounds of bonemeal per acre added. Superphosphate has been found necessary in many soils and should be added in the Spring in preference to bonemeal application in the Fall. It has the tendency to produce earlier flowering and increases reproduction. The best method of application is to spread it in the furrow, before planting, at the rate of five pounds to every 100 feet of row. The material should be covered before the corms are set. With the application of manure in the Fall, and superphosphate in the Spring, additions of other commercial fertilizers are not necessary except just before the flowering spikes appear. Then a nitrogenous fertilizer like urea or ammonium sulphate may be scattered along the rows at the rate of one pound to 100 square feet. The use of nitrogenous and potassic fertilizers, at the time of planting, checks growth and is not beneficial in the production of corms or cormlets. Complete commercial fertilizers, low in these two elements, are often used by commercial growers; 3-12-3, 4-12-4, or 2-16-2 may be used at the same rate and in the same manner as superphosphate.

Lawns.

The lawn area must be considered as a permanent crop, and therefore the preparation of the soil is of paramount importance. Proper drainage is the first essential. The soil should never be water-logged, a condition which is often caused by poor surface grade or by the absence of subsoil drainage. Gentle sloping of the surface and underdraining help matters considerably. If drains are found necessary, a four-inch tile placed at a depth of two feet and with a drop of one-eighth inch to every foot, will serve effectively.

The texture of an ideal lawn soil is loam. Sandy soils are made better by the addition of dry, pulverized clay,

and stiff clay soils are improved by the admixture of sandy and humus materials. Three or four inches of material should be incorporated in either case. When these ingredients are thoroughly mixed by plowing or spading, a fair substitute for loam is obtained.

Barnyard manure is the most common of the humus materials used. The only objection that may be raised to its use is its weed carrying capacity, but even that may be overlooked if it is incorporated deeply in the soil, and if it is used in well rotted form. For a four-inch layer, one ton per 1000 square feet is required.

Sheep manure, leafmold and peat are other materials often recommended for maintaining fertility. Their usefulness lies in later applications. Their cost is too great for initial application. Peat may be used advantageously if about 10 per cent manure is added to it. The manure addition will furnish the needed nitrifying organisms which are lacking in the peat. Outside of this one factor, peat is as good as manure, and in some cases even better, and, in addition, is clean, free from weeds, easily obtained and applied. One hundred pounds will cover an area of 200 square feet, one inch deep.

Since the actual nutrient value of these various humus-adding materials is very low, further application of other elements should be made at the time of the preparation of soil. The lack of phosphorus is noteworthy in many of our lands, and since this material is not very soluble, it may be applied at the time of the initial preparation. Superphosphate should be added at the rate of 25 to 50 pounds to every 1000 square feet. Bonemeal serves the same purpose but is more costly and no better. The use of other fertilizers should be deferred until later.

In the Spring, upon a well established lawn, four pounds of 6-8-6 or 4-12-4 to 100 square feet should be scattered while the lawn is dry and watered in at once. Another

application at half the rate should follow in four weeks. In early August a similar dose should be given. These applications may be supplemented by the addition of ammonium sulphate once or twice during the season at the rate of two pounds to 100 square feet. This nitrogenous fertilizer acts in the dual capacity of nutrient supply and week killer. The stimulus produced causes the leaves of Dandelion and Buckthorn to grow more erect and thus enables the lawn mower to cut them off when operating. This continuous cutting devitalizes the plants, reduces their food supply and eventually they disappear. Certain rules should be observed in the application of commercial fertilizers. The grass should be dry when applications are made. Fertilizers should not be mixed with the seed. Seeding should follow several days after fertilization. All concentrated fertilizers should be watered in at once.

When the soil is well drained and of good texture, the need of liming is questionable. If growth of moss appears, it usually indicates acidity of soil and lime is needed; 10 pounds of ground limestone to 100 square feet provide all the lime needed for three or four years.

During the Winter one often sees lawns covered with strawy manure. The exact object of this practice is hard to understand, unless it acts as a Winter mulch and prevents the heaving of the grass in extremely heavy soils. The notion that it furnishes nutrients is unfounded, since most of the nitrogenous nutrients will be leached out of the manure into the soil and out of the reach of the feeding roots long before these are ready to assimilate them in the Spring.

Roses

Roses will grow in any well prepared soil, provided that drainage and fertility are maintained. Clay soils have been favored because of their water-holding capacity

and the sufficiency of phosphorus and potash supply. Sandy soils may be made retentive of moisture by the addition of humus and may be made fertile through the use of commercial fertilizers.

The humus supply depends upon the incorporation of stable manure, peat or manure and peat at the time of preparing the soil. Peat has been found an excellent substitute for manure in providing all the benefits of the manure except the introduction of the needed bacteria. When these are introduced the use of a small portion of manure with the peat, the latter becomes more valuable than manure. It contains no weeds, has a greater water-holding capacity and is richer in nitrogen. In making Rose beds, either of these materials, or the combination of the two, should form at least one-fourth of the total soil. Sods are often recommended for the making of the soil, but they are not always obtainable and, since their chief virtue lies in their humus content the other two materials usually supersede them.

In the Spring as soon as growth starts superphosphate (four pounds to 100 square feet) should be applied. If bonemeal is preferred, it should be applied in the Fall. Two to three weeks later, potassium chloride should be added in liquid form at the rate of one ounce to two gallons of water. One gallon supplies enough for six square feet. As a substitute for this, two or three ounces of unleached hardwood ashes may be applied to each plant. A week later nitrogenous fertilizers should be applied in liquid form and followed with similar doses once a week; urea, ammonium sulphate, nitrate of soda or potassium nitrate are all useful for this purpose. To eliminate these frequent applications, complete fertilizers may be used two or three times during the season, 4-12-4, 6-8-6 and 15-30-15 being the best mixtures. The first two should be used at the rate of two pounds to 100 square feet, the last at

one-third this rate, or it may be applied in liquid form (one ounce to five gallons). A mulch of well rotted manure or peat is very helpful during the Summer in maintaining fertility, retaining moisture and keeping down weeds. Liming is not necessary unless the soil tests highly acid.

Shrubs and Trees

The majority of trees and shrubs prefer either slightly acid soil or neutral. Very few do well upon alkaline medium and many require acid soils. Among the latter may be mentioned Abelia, Acer spicatum, Aesculus pavia, Andromeda, Azalea, Benzoin, Chionanthus, Clethra, Ilex, Kalmia, Ledum, Magnolia, Myrica, Potentilla, Rhododendron and Stephanandra. The popular notion that shrubs and trees require no feeding is erroneous. They are long-lived crops, and as such should be placed in soil which has been well prepared and its state of fertility kept up with the demands of the plants.

On small places, if the soil has been well prepared by incorporation of manure, further feeding should consist of applying nitrogenous fertilizers in the Spring and a mulch of well rotted manure in the Fall. Ammonium sulphate, nitrate of soda or calcium nitrate may be used. The rate of application should vary with the size of the tree. Usually one-half pound is sufficient. Two pounds to every 100 square feet of bed should be the dosage for shrubs.

This recommendation is based upon experimental data with bush and tree fruits which indicate that nitrogen is the limiting factor in their growth. The same requirements will hold for ornamental trees and shrubs. Due to lack of adequate data with reference to the use of complete fertilizers, quickly soluble nitrogenous forms are to be preferred.

Because of the restricted area available for the spread of street tree roots, and owing to the generally adverse conditions imposed, the soil provided for them should be well enriched. Each tree should have two or three cubic yards of soil, and for this purpose a hole should be dug three feet deep, three feet wide and six feet long. Well rotted manure should be added to good garden loam and, in addition to this, such phosphoric fertilizers as bone-meal, tankage or cottonseed meal at the rate of one pound to every cubic yard. Applications of commercial fertilizers should be made yearly. In this case application of nitrogenous materials alone is not sufficient.

In nursery practices, the best way to supply fertility to the shrubs and trees is by rotation of crops and the use of green manures. The cost of animal manures is prohibitive, and the amount of phosphorus and potash added through their use is so small that they are not practicable for commercial purposes. In addition to the green manures, superphosphate should be added in the Spring at the rate of 1000 pounds to the acre, and potassium chloride at half the amount. These two ingredients furnish sufficient nutrients to produce heavy root growth and stocky stems. If complete mixtures are desired, a 2-10-10, or even those with heavier percentages of potassium and phosphorus may be employed.

Rhododendrons

Rhododendrons, Azaleas, Mountain-laurel and other acid soil loving plants require special preparation of the soil for success. Their need of acidity has been recognized for many years, but in recent years the experiments of Dr. F. V. Coville of U. S. D. A. have clarified matters and the recommendations are taken from his work:

When the soil in which these plants are to grow is alkaline it is necessary to make up a special mixture.

This should consist of one part clean sand to four parts of acid peat. The depth of this mixture need not be more than 12 inches. A permanent mulch of Oak leaves will maintain a proper degree of moisture and will supplement the peat supply. Leaves of Maple, Elm and Basswood decompose readily and turn alkaline.

No manure, lime or wood ashes should be applied to these acid loving plants. Cottonseed meal, Soy Beans or spent malt contain organic nitrogen in acid form and may be used with safety. A complete mixture applied at the rate of one-fourth pound to one square yard is very satisfactory. It is made up of cottonseed meal, ten pounds; superphosphate, four pounds; sulphate of potash, two pounds.

In order to secure or maintain acidity for these plants, ammonium sulphate (one pound to 10 square feet), commercial tannic acid (one part to 50 parts of water) may be applied to the soil or partially rotted sawdust used as a mulch.

CHAPTER VIII

OUTDOOR VEGETABLES

ASPARAGUS

Soil

ASPARAGUS requires a deep, loose, fertile and well drained soil. Since sandy types are warmer, they produce an earlier crop in the Spring and are therefore more satisfactory for the market gardener. However, excellent crops are produced on deep, highly decomposed muck. The soil must be well drained, as the roots are injured if submerged in water any length of time. Muck is often harmful in this respect.

Fertilizers

Since the yields and profitableness of any plantation depends largely on the care given and the amount of fertilizer applied, liberal amounts of manure and fertilizers are necessary. Under ordinary conditions, a plantation should remain highly productive for at least ten to fifteen years. To maintain vigor of the stems, a moderate application of manure (10 to 20 tons per acre) should be made, each year if possible, just before or immediately after the cutting season and thoroughly disked into the soil. If manure is unavailable, 1000 to 1500 pounds of a high analysis commercial fertilizer should produce good results. In many cases the use of manure and commercial fertilizers combined has been highly

satisfactory. An annual application of nitrogenous fertilizer (sulphate of ammonia or nitrate of soda), at the rate of 200 to 300 pounds per acre, should always be made immediately after the cutting season to induce vigorous stalk growth and resistance to rust, a very destructive disease.

BEANS

Soils

Beans thrive best on deep, well drained, loamy soils. Early crops should be raised on sandy loams, and mid-season or late crops on heavier types. A very rich soil should be avoided to prevent development of excessive vine growth. Poorly drained soils are generally unsatisfactory. Unless the soil is very acid, Beans do not require lime.

Fertilizers

Manure should be applied to the crop grown just previous to Beans. The large quantity of available nitrogen in manure tends to produce excessive vine growth and decreased yields. Superphosphate is the principal fertilizer. On sandy loams, a 5-10-5, a 4-8-4 or a 4-16-4 or any similar mixture high in superphosphate, applied at 500 to 1000 pounds per acre, should give good results. The proper proportion of phosphorus to nitrogen and potash depends largely on the character of the soil, previous fertilization and the rotation.

Small applications of fertilizers (less than 300 pounds per acre) should be applied in the row previous to planting. Up to 300 pounds of larger applications may be applied in a row and the remainder broadcasted. There is some indication that large amounts of fertilizer (more than 300 pounds per acre) applied in rows may retard germination and subsequent growth. This is true especially on light types of soil

On clay loams, superphosphate applied at the rate of 300 to 500 pounds per acre generally produces the most satisfactory results.

CABBAGE AND CAULIFLOWER

Soils

Early Cabbage and Cauliflower are produced most advantageously on sands and sandy loams, preferably with southerly exposure; later crops, in which total yield is of great importance, generally grow best on heavier soils and on sweet mucks. In either case, though the soil should be retentive of moisture, it should be well drained, for the crops are very sensitive to a water-logged condition of the soil. Cabbage and Cauliflower soils should contain large quantities of organic matter, which enable them to retain more moisture during periods of dry weather.

Fertilizers

Fertilization of Cabbage and Cauliflower crops is profitable in most cases; for this a combination of manure and commercial fertilizer is advantageous. Moderate applications of manure (16 tons per acre), supplemented with chemical fertilizers, should produce higher yields than large amounts of manure (32 tons per acre) applied alone. The commercial fertilizer requirements depend on the type of soil on which the crop is grown. On sands and sandy loams a fertilizer analyzing four to five per cent nitrogen, 10 to 16 per cent phosphoric acid, and four to five per cent potash, applied in three or four doses totalling 1000 to 1500 pounds to the acre, is recommended. Small and frequent doses produce better results in earliness than large and infrequent doses aggregating the same amount. For the late crop, the fertilizer should be applied in one dose at the time the ground is being prepared for setting. On clays and clay loams, acid phosphate applied

at the rate of 500 to 700 pounds per acre, is recommended. For the production of crops for the early market, or in the case of plants for any market, which are retarded in growth during the early part of the growing season, a side dressing of 100 to 150 pounds of nitrate of soda to the acre will promote earliness of maturity. On muck soils, which are usually deficient in potash, an application of 1000 to 1500 pounds to the acre of a 2-8-24 mixture is suggested. Whenever feasible, Cabbage or Cauliflower should follow the legume crop in the rotation.

Lime

On acid soils, applications of lime in moderate quantities (1000 to 2000 pounds per acre) is likely to be advisable, from its effect on growth and from the check it gives to club root, a rather serious disease. Lime should not be applied with manure or commercial fertilizers.

CELERY

Soils

A large proportion of the commercial Celery crop is produced on muck land. In general, a deep muck, fairly high in lime content, is preferred, but good crops can be grown on shallow muck if it is not drained too deep. A muck which is at all liable to drought is not satisfactory for the crop. Fair yields can be secured on upland (mineral soil), if it is in a high state of fertility and the moisture supply is satisfactory.

Fertilizer

Muck soils suited to growing Celery almost uniformly contain comparatively small amounts of two important fertilizing constituents; namely, potash and phosphoric acid. Though they are relatively high in nitrogen, this ingredient is only slowly available to the Celery plant.

On such soils heavy applications of fertilizer are necessary for high yields of a rapidly growing crop such as Celery.

Though manure is sometimes applied in regular amounts to muck soils, it can generally be omitted and better yields are usually secured with commercial fertilizer. On muck soil, a commercial fertilizer having the formula 0-8-24 is recommended for late Celery when manure has been applied. When manure is not applied, a 3-8-24 mixture with a side dressing of 200 to 300 pounds per acre of nitrate of soda or sulphate of ammonia, should be used. On late Celery, an application of 200 to 300 pounds per acre of nitrate of soda, about the time of banking, is advisable if the weather is cold. The application of complete fertilizer recommended ranges from 1000 to 1800 pounds per acre with the single crop system, depending on the amount of manure used and the previous fertilization of the field. Where two or more crops are grown each year, these amounts should be increased by about one-fourth for each additional crop.

On mineral soils the use of manure for Celery is highly recommended. This should be supplemented with commercial fertilizer. Smaller proportions of potash are needed here than on muck land; a mixture analyzing three to four per cent nitrogen, 12 to 16 per cent superphosphate and four to six per cent potash, is recommended. An application of 800 to 1500 pounds per acre should suffice.

LETTUCE

Soils

Lettuce usually thrives best on sandy loams and mucks. Sandy loams are better for the early crop, due to earlier planting possible and the resultant early maturity. In any case, the soil should be deep, friable, well drained and fairly retentive of moisture. Mucks containing fair amounts of lime are very satisfactory for the main crop,

due to its humus content, water retaining power and supply of nitrogen.

Fertilizers

Since rapid growth is essential to crispness and high quality, there must be a liberal amount of available nutrients in the soil. On mucks, a commercial fertilizer containing two per cent nitrogen, eight per cent phosphorus and 16 per cent potash gives good results. On sandy soils the use of either manure or cover crops to maintain the humus content, combined with commercial fertilizer is desirable. A fertilizer analyzing 4-10-4, with some manure, has given very good results on sandy loam. The amount applied varies from 500 to 2000 pounds per acre, depending on the fertility of the soil and the amount of manure used. The most common method of application is by broadcasting at the time of planting. An additional application of 200 pounds of nitrate of soda, two weeks after planting, is often advisable in cool weather.

MUSKMELONS

Soils

Muskmelons thrive best on deep, friable, well drained sandy loams. This type of soil is most favorable to rapid root growth, vine development and earliness of maturity. The soil must be mellow and well supplied with organic matter. Melons growing in soils lacking in organic matter are likely to become checked in growth during periods of drought.

Fertilizers

Barnyard manure should be applied, or green manuring crops grown, to maintain the humus content of the soil, and commercial fertilizers applied to furnish nutrients to the crop. Green manuring crops may either supplement

light manure applications or completely take the place of manure. Alfalfa, Red Clover, Sweet Clover, Vetch with Rye or Oats, and Barley should be grown, depending upon the length of the rotation and the type of soil. For long rotations (four to five years) Alfalfa and Sweet Clover are recommended. These crops put the soil in excellent condition for Cantaloupe production. Of the non-leguminous crops, Rye is the most satisfactory because of its adaptability to light types of soil, rapid growth and resistance to cold. Sowing, at the rate of one bushel per acre, during or immediately after the harvesting season, secures a good stand of Rye for turning under in the Spring.

Manure is either broadcasted, preferably by means of a manure spreader, before the land is plowed, or applied in hills in furrows at the intersection of the marks and covered with the plow. Poultry manure is sometimes used in hills. This material should be used sparingly and thoroughly mixed with the soil.

CUCUMBERS

Soils

Cucumbers thrive on any well drained fertile soil. Crops for early market are usually grown on sandy loams. Pickling Cucumbers are usually raised on heavier soil types since large yields are most important. In any case, the soil should be well supplied with organic matter to increase the water holding capacity.

Fertilizers

Though Cucumbers do not draw heavily upon the fertility of the soil, applications of commercial fertilizer are usually necessary to promote steady, vigorous growth. Soils for Cucumbers should contain large quantities of organic matter. In case large amounts of manure (more

than 20 tons per acre) are available it should be broadcasted and plowed under. If the supply is limited it should be used in the hill, although in this manner it is likely to retard growth during a dry season. Manure should always be amended with acid phosphate at the rate of 40 to 50 pounds for every ton. In any crop rotation, Cucumbers should not follow Sugar Beets, Cabbage, Potatoes or Oats, unless the soil has received additional organic matter, either in the form of manure or a green manuring crop. It is wise to follow the green manuring crop with cucumbers.

If commercial fertilizer only is used, it may be broadcasted immediately after plowing and the subsequent harrowing will thoroughly mix it with the soil. A mixture containing three to four per cent nitrogen, 12 to 16 per cent available phosphoric acid and six to eight per cent potash is suggested. A "4-16-4" fertilizer can be obtained from almost any manufacturer or dealer in supplies of this kind. From 300 to 1000 pounds, depending upon soil conditions, should be used per acre. If amounts less than 300 pounds to the acre are used, applications in the furrow are recommended, though care should be taken that none come in contact with the germinating seed. For amounts in excess of 300 pounds to the acre, broadcast application is recommended. The best results will be obtained from commercial fertilizers only when the soil is in good physical condition and well supplied with humus. They will not replace good seed bed preparation or good tillage, and should be supplemented by occasional plowing under of green manuring crops.

HORSERADISH

Soil

Horseradish requires a deep, rich, moist, well drained loamy soil. If the soil is compact the roots have a tendency

to grow much branched and crooked. Shallow soils underlaid with a heavy clay should be avoided. The deep black, highly fertile river bottom lands in the vicinity of St. Louis are the chief factors in the development of the largest producing area at the point.

Fertilizers

The amount and kind of fertilizer advisable depends on the fertility of the soil. Unless the soil is rich and in good physical condition, it should receive heavy applications of well rotted manure. Better results will be obtained if the manure is supplemented with 40 pounds of acid phosphate to every ton. When manure is not available, the application of 1000 to 1500 pounds of a 5-10-5, a 4-8-4, a 5-8-7 or a 4-12-4 fertilizer will give good results, unless the soil is already fertile. On a fertile soil somewhat smaller quantities should be used.

ONIONS

Soils

Although Onions are grown on certain mineral soils, sandy loams and silt loams, commercial production of the crop is usually confined to muck, except in the Texas area. Suitable mucks are well drained, highly decomposed, compact and very fertile. Since the Onion plant is not tolerant to acidity, it grows best on the so-called highlime mucks.

Fertilization on Muck Soil

Commercial mixtures between 0-12-12 and 4-8-24 have been found satisfactory for the commercial production of Onions on muck soils. The best formula depends on the acidity of the muck, its depth, age of soil and the maturity of the crop.

For an early crop grown on newly reclaimed or shallow muck, an excellent fertilizer is either 0-12-24 or 0-16-24.

The latter should be applied on mucks which tend to retard earliness of the crop. For the late crop the proportion of phosphoric acid to potash should be greater—0-24-24 on newly reclaimed mucks and 0-12-24 on old or shallow mucks. The rate of application varies from 800 to 1500 lbs. per acre.

Nitrogen applied in readily available forms (nitrate of soda or sulphate of ammonia) generally increases the yield and hastens maturity of the crop. Unless the soil is very shallow and poorly drained, nitrogen is not needed with the late crop.

In general, applications made in the rows produce better yields than those broadcasted. A given amount of fertilizer distributed in two or three applications, during the first two months of growth, produces higher yields than one application made just before planting time.

Fertilization on Mineral Soils

On mineral soils a mixture containing a smaller proportion of potash than is needed on muck soil is advised, a 4-12-4 or 4-16-4 being recommended. Applications ranging from 800 to 1500 pounds per acre should be sufficient.

Liming

On distinctly acid mucks, liming should be practiced for several years until the lime has become thoroughly incorporated in the soil and the acidity greatly reduced before Onion production is attempted. On the so-called sweet mucks, lime is unnecessary and may even reduce yields.

PEAS

Soils

Peas succeed on a wide variety of soil types if the soils are well drained. The roots of the Pea plant cannot with-

stand a waterlogged condition of the soil. Market gardeners usually prefer sandy loams since they induce early maturity of the crop. Heavier soils are used for late or canning crops.

Fertilizers

Since nitrogen in manure is likely to produce excessive vine crop, it should not be applied directly to land growing Peas. It should preferably be applied to the crop preceding Peas. Authorities generally agree that phosphorus is the element most needed. On sandy loams with crops for early market, a mixture (4-12-4 or 4 16-4) applied at 500 to 1000 pounds per acre, is recommended. On heavier soils, 300 to 500 pounds of superphosphate is advised. Application of lime in moderate quantities is likely to produce beneficial results on distinctly acid soils.

POTATOES

Soils

For successful Potato growing, mineral soils require the addition of large amounts of organic matter. This material improves texture and aeration and makes the soil generally favorable for development of the tubers. Ideal soils are very fertile, of medium texture, friable, deep and acid in reaction. Potatoes are grown generally on sandy loams and mucks.

Fertilizers

Manure should be applied during the growing season, previous to planting, or uniformly distributed as a top dressing at the rate of 10 to 20 tons per acre when the soil is prepared for the crop. The use of fresh stable manure should be avoided. In case manure is unavailable, green manuring crops should be grown to precede Potatoes in the rotation, since they supply organic matter to the soil and increase the water holding capacity.

A high analysis fertilizer should be used to supplement either manure applications or a green manuring crop. On sandy loams, mixtures having proportions 3-12-4, 4-12-4 or 4-16-4 are generally used. In Connecticut a 5-8-7 mixture is employed. Soils well supplied with organic matter, such as the clay loams, are likely to produce the most profitable returns with applications of superphosphate alone, at 500 to 1000 pounds per acre.

On mucks suitable for Onion production, commercial mixtures with formulas ranging around 2-12-12 or 2-8-16 or 2-8-24 are recommended. The rate of application should range from 800 to 1500 pounds per acre, depending on the type of muck and on the fertilization and yields of preceding years. In some states excellent results have been secured from applications of fertilizer in the row; these applications should be made preferably on the same level with and a little distance away from the seed piece. To avoid serious burning to the sprouts, fertilizers should never be allowed to come in contact with the seed.

Liming

To lessen the possibility of injury from scab, lime applications should be avoided. In case lime is necessary, it should be applied to some crop in the rotation having greater lime requirements, preferably to the legume crop —Alfalfa, Sweet or Red Clover. The rate of lime application depends on the type of soil, previous fertilization and the rotation. The lime requirement should be determined before applications are made. Many mucks which have an alkaline reaction, due to burning over or presence of marl near the surface, are unsuited to Potato production.

RHUBARB

Soils

Rhubarb can be grown on a wide range of soils. However, the crop thrives best on well drained, deep, rich,

sandy loams with southerly exposures. Soils high in moisture and in humus produce the best stems.

Fertilizing

Well rotted manure, especially cow manure, seems to be the most valuable fertilizing material for Rhubarb. This should be applied in the late Fall or early Winter. Where manure is scarce or unobtainable, many commercial growers use high-grade commercial fertilizers. Annual applications totalling 1000 to 1500 pounds of commercial fertilizer in the form of 5-10-5 or a 4 12-4 mixture, may be justified. Applications may be made in the early Spring or in late Summer or early Fall. The manure or complete fertilizer should be supplemented with nitrate of soda or sulphate of ammonia (200 to 300 pounds per acre), applied immediately after the harvesting season to induce the production of large stems.

Liming

On distinctly acid soils given over to Rhubarb, moderate applications of lime are likely to be profitable; on neutral or on slightly acid soils Rhubarb should not require lime.

ROOT CROPS—BEETS, CARROTS, TURNIPS, RUTABAGAS

Soils

Root crops require deep, well drained, loose, friable soils. Early crops are usually raised on sandy loams and late crops on silts, silt loams and mucks. All of these crops except the Beet grow best on slightly acid soils; the Beet requires a neutral soil.

Fertilizers

Though organic matter is essential, it should never be applied in the form of fresh manure, since this material is likely to contain large quantities of weed seed and an excess of nitrogen.

Rotten manure or green manuring crops should be used and supplemented with commercial fertilizers. Manure applications may range from 15 to 20 tons per acre, broadcasted when the ground is prepared. The kind and amount of fertilizer necessary depends on the type and fertility of the soil, previous fertilization, the rotation and time of maturity. On sandy loams, fairly high in organic matter, a 3-12-4 or a 4-12-4 fertilizer can be recommended. On silts and silt loams, the proportion of nitrogen may be decreased. On muck soils a 0-12-12, 0-12-24, 2-8-16 or 2-8-24 mixture is advised. The proper rate of application ranges from 800 to 1500 pounds per acre.

SPINACH

Soils

Spinach thrives on a wide range of soil types. The greatest yields are usually secured from silt and clay loams; sandy loams are usually preferred for Winter crops and sweet mucks are sometimes used especially for growing Spinach for the cannery. In any case, soils for Spinach should be well drained and fairly fertile.

Fertilizers

On mineral soils, stable manure, especially fresh manure, should always be applied to a crop preceding Spinach. Nitrogen is undoubtedly the most important fertilizer element for Spinach, and a gradually available supply is necessary. For Spring and Fall crops, a complete mixture analyzing 4-8-4 or 4-8-6, applied at 1000 to 1500 pounds per acre, supplemented with nitrate of soda, sulphate of ammonia or high-grade tankage at 100 to 150, 200 to 250, or 300 to 400 pounds per acre, respectively, should produce satisfactory crops. Though a common practice in some sections is to apply the fertilizer before and after planting, good results have been obtained by ap-

plying the whole amount at once, working it into the soil when the beds are being prepared. The vigor and growth of the plants should determine the advisability of applying nitrogen during the growing season. Frequently, cold weather and the growing of this crop on light, porous soils necessitate one or two top dressings of quickly available nitrogenous fertilizer.

On muck soil, a complete fertilizer mixture high in potash (2-8-16 or 2-8-24), applied at 800 to 1500 pounds per acre, is advised.

Liming

Soils for Spinach should be very slightly acid. The Spinach plant is sensitive to large amounts of acidity on the one hand, and to excessive alkalinity on the other. Yellowing and browning of the margins and tips of the leaves and browning of the roots occur on excessively acid soils. Yellowing of the leaves, especially along the veins, is likely to occur on alkaline soils.

Spinach should not be grown in rotation with Potatoes, Watermelons, Tomatoes, or any other acid tolerant crop, nor should it follow crops requiring large amounts of lime. Chlorosis and arrested growth due to excessive alkalinity have been corrected by applying manganese sulphate at the rate of five to ten pounds per acre.

SWEET CORN

Soils

Sweet Corn is grown on a great variety of soils depending on the purpose for which the crop is grown. Growers for early market prefer well drained sandy loams with southerly exposure, since these soils warm up early in the Spring and mature a crop before drought occurs. Growers for the cannery, being interested in yields rather than in earliness, select silts, silt loams and clay loams.

Manures and Fertilizers

Sweet Corn should be grown in a definite system of crop rotation, preferably following a legume or green manuring crop. To induce earliness of maturity, fertilizers are far more effective if applied at planting time one-half to three-fourths inch above the kernel in hills, rather than broadcast. Hill applications should total from 100 to 200 pounds per acre, depending on the type of soil. There is danger of injury to the seed if large quantities are used. To avoid possible retardation in germination, fertilizers should never come in contact with the seed. This is more likely to occur on sandy soils than on clay soils. Additional applications should be broadcasted at the rate of 500 to 1500 pounds per acre, to maintain growth and vigor.

Since the same mixture, method and rate of application will not give the same results on all types of soils and under different climatic conditions, growers should determine the best combination of fertilizer and method to meet their own particular conditions.

Fertilizers high in superphosphate are generally most satisfactory for the growing of Sweet Corn. Good results have been obtained with the following formulae at the various stations indicated: 2-12-2 and 3-10-4, Wisconsin (all types of soils); 0-16-6, Illinois (clay loam); 3-10-4, Michigan (sandy loam).

Growers of Sweet Corn for seed or for the cannery should always supplement manure with superphosphate at the rate of 40 pounds for every ton of manure used. In case manure is unavailable, green manuring crops should be grown in a definite rotation and turned under and supplemented with superphosphate at the rate of 300 to 500 pounds per acre.

Liming

Unless the soil is distinctly acid, lime is not needed for Sweet Corn. In most cases, applying lime to some other crop in the rotation, usually the green manure crop, produces most satisfactory results.

TOMATO

Soils

The Tomato thrives on a great variety of soil types, ranging from the light sands to the heavy clays. Under extensive methods of culture, as in the case of Tomatoes grown for the cannery, where low production cost is important and earliness not essential, clay or silt loams are desirable. Where earliness is important, however, a warm, sandy loam with southerly exposure would be better. In both cases, soils should be well drained, contain plenty of organic matter and fertility.

Fertilizers

Commercial fertilizers should be used always on Tomatoes. Most authorities agree that superphosphate is the most important single fertilizer ingredient. On heavy soils, fertilizers containing liberal amounts of nitrate (sodium nitrate or ammonium sulphate) or potash tend to produce excessive vegetative growth and late maturity. However, if plants are potbound or stunted they should be given a nitrate solution just before they are set in the field. This will induce growth and earliness of maturity. Since phosphates tend to hasten maturity, fertilizers used in the Northern States, where the growing season is short, should be high in this material. Crops grown on rich soils for the cannery, especially when they follow a green manuring crop or manure application, should receive superphosphate alone (500 to 1000 pounds

per acre). In case manure or a green manuring crop is not used, a complete mixture (3-12-4) (5-10-5) (4-8-4) or (5-8-7) at 500 to 1000 pounds per acre is advised. On sandy loams, manure (10 to 20 tons per acre), or a green manuring crop (Alfalfa, Sweet Clover, Red Clover, Rye and Vetch) should be turned under during the growing season preceding the Tomato crop, and a 4-12-4 or 4-16-4 fertilizer, applied at 500 to 1500 pounds per acre. Commercial mixtures should be applied at planting time rather than after the plants have been set. Applications of less than 500 pounds per acre should be made in the row; larger amounts may be broadcasted. Fresh manures should never be used with the Tomato crop.

SWEET POTATO

Soils

Most authorities agree that Sweet Potatoes thrive best on fairly acid, fairly fertile soils. Well drained, light, sandy loams underlaid with clay are considered best. Heavy soils, because of their texture and high fertility, are likely to produce large, misshapen, unmarketable roots and excessive vine growth. The experience of growers in most sections indicates that liming is likely to produce large, rough and unmarketable roots. However, there is some indication that liming is very beneficial on poor soils which are distinctly acid.

Fertilization

Since commercial fertilizers markedly influence the amount and quality of the yield, their careful selection and application is necessary. Excessive nitrogen, either from applications of manure or commercial fertilizer, favors the development of excessive vine growth and elongated tubers. On the other hand, phosphorus and potassium are likely to produce a greater percentage of marketable roots of high quality. There is some indica-

tion that better yields can be secured from potassium in the muriate form than that in combination with sulphate. The kind and amount of fertilizer necessary depends on the fertility of the soil, previous fertilization and intensiveness practiced. Unless the soil is very infertile, manure should be applied to the crop preceding Sweet Potatoes. In the trucking regions in the North, where earliness of maturity is particularly important, commercial mixtures analyzing three to four cent nitrogen, eight to ten per cent superphosphate, and six to eight per cent potash, applied on light sandy loams at the rate of 1000 to 1500 pounds per acre, should produce satisfactory crops. On heavy types of sandy loam the percentage of nitrogen may be decreased. In cases where the crop is given in rotation with general farm crops, lesser quantities of commercial fertilizers are used.

Commercial fertilizers are applied in the row or broadcasted or both. Small quantities (less than 500 pounds per acre) should be applied in the row, preferably before the plants are set. Larger quantities should be broadcasted to avoid serious burning of the plants. There is some indication that frequent applications produce better results than one application totalling the same amount. The first application should be made in the row just before the plants are set, and succeeding applications at intervals of 10 to 15 days.

WATERMELONS, PUMPKINS AND SQUASH

Fertilizers

Applications in hills are likely to be the most profitable for Watermelons, Pumpkins and Squash. In general, two applications suffice. The first should be made when the plants appear and the second when the vines begin to run. Not more than 300 pounds should be used in each application. Complete mixtures, high in phosphorus, should be used.

TABLE I—FLOWERING CROPS

Crop	Soil	Fertilizers: Time of Application	Fertilizers: Kind	Fertilizers: Amount
Rose.............	Medium clay loam; 1/4 manure	At planting and once a year in Summer after drying off.	Superphosphate, 20 per cent	10 lbs. to 100 sq. ft.
		After January bi-weekly	Liquid manure, Urea, Nitrate of Soda, Ammonium sulphate	1 oz. to 10 gals. 1 oz. to 2 gals.
		After January supplement once in four weeks	4–12–4	4 lbs. to 100 sq. ft.
Carnation..	Sandy loam prepared in field with cover crops or 1/4 manure	At planting	Superphosphate	10 lbs. to 100 sq. ft.
		October	Tankage	3 lbs. to 100 sq. ft.
		February and once a month thereafter	4–12–4 or 15–30–15	2 lbs. to 100 sq. ft. 1 oz. to 10 gals.
Chrysanthemum...	Fibrous loam 1/5 manure	At planting	Peat, superphosphate	1 in. mulch
		When taking buds and bi-weekly until color shows	Urea Ammonium sulphate 4–12–4 15–30–15	1 oz to 10 gals. 1 oz. to 2 gals. 3 lbs. to 100 sq. ft. 1 lb. to 100 sq. ft.

Sweet Pea	Well drained deep, medium-heavy soil	At planting	Manure, superphosphate and lime	5 lbs. to 100 linear ft.
		After six weeks every three weeks	4–12–4 or 6–8–6	5 lbs. to 100 linear ft.
	On light soils	When 12 in. high	Hardwood ashes or Potassium chloride	10 lbs. to 100 linear ft. 3 lbs. to 100 linear ft.
Snapdragon	Light loam, well manured	At planting	Peat Superphosphate	1 in. mulch 5 lbs. to 100 sq. ft.
		February on, every two weeks	Urea Ammonium sulphate 4–12–4	Liquid Liquid 3 lbs. to 100 sq. ft.
Violet	Medium heavy sod	At planting	Horse manure	1–5
		November	Peat	Mulch
		February	4–12–4	1 lb. to 100 sq. ft.
Bulbs	Medium heavy loam, ¼ well rotted manure or leafmold	At planting	Superphosphate	
		When buds show	Urea, or Calcium nitrate	Liquid
Gladiolus	Rich, sandy loam	At planting	Superphosphate	5 lbs. to 100 ft. of row
		When buds show, once in two weeks	Urea followed by 4–12–4 or 15–30–15	Liquid 4 lbs. to 100 ft. 2 lbs. to 100 ft.

TABLE II—POT PLANTS

Crop	Soil	Fertilizers		
		Time of Application	Kind	Amount
Adiantum. .	Fibrous, sandy loam; 1/4 manure, leafmold or peat	Toward end of season, two applications	4–12–4 or Urea	1 oz. to six 6-in. pots Liquid
Asparagus plumosus and sprengeri.	Heavy loam; 1/4 manure	When potting After first shift Later	Superphosphate 4–12–4 Urea or 15–30-15	4-in. pot to bushel 4-in. pot to bushel Liquid
Azalea	Turfy loam with peat or leafmold	When potting Month before bloom To secure acidity	4–12–4 Peat Aluminum sulphate	4-in. pot to bushel Mulch 3-in. pot to bushel
Bedding Plants. . . .	Light loam; 1/5 manure	When potting Later	4–12–4 Urea or 4–12–4	As before given Liquid 1 oz. to six pots
Begonia	Light sandy loam; 1/3 peat, leafmold or manure	When potting Later potting Winter flowering every three weeks	Superphosphate 4–12–4 Urea or Ammonium sulphate	 Liquid
Calceolaria.	Light sandy loam	When potting When shifting, add After final shift, once in two weeks	Superphosphate 4–12–4 15–30–15 or 20–30–20	 Liquid
Cineraria	Coarse, light loam; 1/4 manure	When potting and shifting, add	Superphosphate and 4–12–4	
Cyclamen.	Sandy loam; 1/4 manure, leafmold or peat	When potting When in 4-in. pots When in 5-in. pots	Superhosphate 4–12–4 Urea or 4–12–4 or 15–30–15	

Ferns.	Fibrous loam; ¼ manure or leafmold	When potting When well rotted When potting	Superphosphate Urea, dried blood or liquid manure Horn shavings or bonemeal	4-in. pot to bushel
Fuchsia	Two parts loam, one part manure, one part leafmold	When potting Final shift	Superphosphate 4–12–4	
Hydrangea........	Heavy loam; ¼ manure	When potting Later, twice also	Superphosphate or bonemeal Potassium chloride Urea	Liquid, 1 oz. to 1 gal. Liquid
Palms............	Heavy fibrous loam	When potting Later	Bonemeal and ¼ manure Urea	Liquid
Pelargonium......	Coarse loam; ¼ manure	Last shift	4–12–4	
Poinsettia.........	Heavy loam; ⅓ manure	Last shift	Superphosphate	
Primrose.	Light, sandy; ¼ leafmold	Last shift Later, once in three weeks	Superphosphate 4–12–4	
Rose.	Medium heavy; ¼ manure	When potting Onr month before flowering When buds show	Superphosphate 4–12–4 or 6–8–6 Same	Top dress
Tropical Foliage...	Medium heavy loam, ¼ manure	Top dress Spring and Summer	Peat and 4–12–4 or 15-30–15	
Vinca............	Light loam; ⅕ manure	When potting Later in Spring	4–12–4 Urea or liquid manure	

TABLE III—OUTDOOR ORNAMENTAL CROPS

Crop	Soil	Fertilizers		
		Time of Application	Kind	Amount
Annuals. . .	Varying	Fall	Manure	4 to 6 inches
		Spring, after planting	Superphosphate	10 lbs. to 100 sq. ft.
			4–12–14, or	4 lbs. to 100 sq. ft.
			15–30–15, or	1 lb. to 100 sq. ft.
			6–8–6	4 lbs. to 100 sq. ft.
		Follow with	Peat	Mulch
		In July	Same as above	
Sweet Peas. . .	Deep, medium heavy loam	Fall	Manure	Trench
		Spring	Superphosphate	10 lbs. to 100 linear ft.
			Lime	10 lbs. to 100 linear ft.
		After first picking	4–12–4, or 6–8–6	4 lbs. to 100 linear ft
		Later	Urea, calcium nitrate or liquid manure	
Strawflowers	Medium heavy	At planting	2–10–10	1000 lbs. to acre
Herbaceous perennials. . . .	Varying	Fall	Manure	
		Spring	Superphosphate	
		Summer, two applications	4–12–4, or 15–30–15	
Iris . .	Medium loan	Season before	Green manures	
		Spring	Urea or calcium nitrate or ammonium sulphate	Liquid Dry
		After flowering	2–10–10	3 lbs. to 100 sq. ft.
Peony.	Heavy loam, limed	Fall	Bonemeal	
		Spring	Superphosphate and potassium sulphate	10 lbs. to 100 sq. ft. 3 lbs. to 100 sq. ft
		After bloom	2–10–10 Peat	Mulch

Bulbs.		Fertilize crop preceding them.		
Lilies.	Varying, deep, fertile	No manure in contact		
		Fall	Bonemeal	
		Spring	Superphosphate 2–16 2	10 lbs. to 100 sq. ft.
Dahlia.	Light loam manured	Fall	Bonemeal	
		Spring	Superphosphate	
		When tops reach 12 in.	2–10–10, or 2–10–6	3 oz. to plant
		Later	Ammonium sulphate or urea, or 15–30–15	Liquid
		Also	Peat	Mulch
Gladiolus	Light loam, slightly acid	Fall	Manure, lime if needed, Bonemeal	1000 lbs. to acre
		Spring	Superphosphate or 3–12–3 or 4–12–4 or 2–16–2	800 lbs. to acre
		When spikes show	Ammonium sulphate	1 lb. to 100 linear ft.
Lawn.	Loam	Fall	Manure, bonemeal	5 lbs. to 100 sq. ft.
		Spring	Superphosphate	
		Follow in four weeks	4–12–4 or 6–8–6	4 lbs. to 100 sq. ft.
		Follow by	Ammonium sulphate or urea	1 lb. Liquid
		August	4–12–4	
Rose	Heavy loam	Fall	Manure, bonemeal	
		Spring	Superphosphate	
		Two weeks later	Potassium chloride	Liquid, 1 oz. to 2 gals.
		Once in two weeks	Ammonium sulphate or urea	Liquid
		July	4–12–4	
		All season	Peat	Mulch

TABLE IV—GREENHOUSE VEGETABLES

Crop	Soil Acidity	Soils	
		Sandy Loams	Clay Loams
Tomato	Medium acid	Superphosphate 4–12–4 5–10–5 4–16–4 15–30–15	Superphosphate 4–12–6 4–12–4 2–16–2
Cucumber	Slightly acid	4–12–4 5–10–5 4–16–4	3–12–3 4–12–4 2–16–2 Superphostate
Lettuce	Slightly acid	4–12–4 5–10–5	Superphostate 2–16–2
Radish	Medium acid	4–8–6 5–8–7 2–12–6	0–14–4 2–12–6 3–12–6

TABLE V—OUTDOOR VEGETABLE CROPS

Crop	Soil Reaction	Soils: Sandy and light sandy loams — Manure in rotation	Sandy and light sandy loams — Green manuring crops in rotation	Sandy and light sandy loams — No manure or green manuring crops in rotation	Heavy sandy loams, silt loams and clay loams — Manure in rotation	Heavy sandy loams, silt loams and clay loams — Green manuring crops in rotation	Heavy sandy loams, silt loams and clay loams — No manure or green manuring crops in rotation	Muck
Spinach. . .	Very slightly acid	4–8–6	4–8–6	4–8–4 5–8–7 Nitrate of soda Sulphate of ammonia Tankage	3–8–6	3–8–6	4–8–6	2–8–16
Lettuce.	Very slightly acid	3–12–4	3–12–4	4–12–4 Nitrate of soda	0–12–0	0–12–6	2–12–2	2–8–16
Celery.	Very slightly acid	3–12–4	3–12–4	4–12–4 4–16–4	3–12–4	4–12–4	4–12–4	0–12–12 2–8–24 2–8–16
Cabbage and Cauliflower	Very slightly acid	4–12–4	4–12–4	5–12–5	2–12–6	2–12–6	3–12–4	2–8–24
Root crops. . . .	Beets slightly acid, others moderately acid	2–12–6 3–12–4	2–12–6 3–12–4 5–10–5	5–8–7 4–12–4 5–10–5	3–8–4	3–8–4	4–8–4 5–10–5	2–8–16 0–8–16

TABLE V—OUTDOOR VEGETABLE CROPS—Continued

Onion........	Very slightly acid	3–12–4	3–12–4	4–12–4 4–16–4	3–12–4 0–12–0			0–12–12 2–8–16
Potato.... ..	Moderately acid	0–16–0 0–14–4	0–16–0 2–16–2 2–12–6	4–12–4 3–12 4 5–10–5	0–16–0 0–14–4 2–12–2	2–16–2 2–12–2 0–16–0	4–12–4 3–8–6	0–8–24
Beans.	Moderately acid	2–12–2 0–16–0	2–12–2 3–12–4	4–12–4 4–16–4	0–16–0	0–16–0	2–16–2	
Peas	Very slightly acid	2–12–2 0–16–0 2–12–2	2–12–2 3–12–4 2–12–6	4–12–4 4–16–4 5–10–5	0–16–0 2–12–0	0–16–0 2–12–0	2–16–2 2–12–6	
Tomatoes. ...	Moderately acid	2–16–2 3–12–4	3–12–4 4–12–4	5–8–7 4–12–4 4–16–4 5–10–5	0–16–0 2–16–2	0–16–0 2–16–2 3–12–4	4–12–4 5–10–5	
Cucumbers..	Very slightly acid	3–12–4 2–16–2	4–12–4 4–16–4	4–12–4 5–10–5	0–16–0 2–12–2	2–12–2 3–12–4	3–12–4 4–16–4	
Cantaloupe.	Very slightly acid	3–12–4 2–12–2 2–16–2	3–12–4 4–12–4 5–10–5	4–16–4 5–10–5	0–16–0 2–16–2	3–12–4 2–16–2	4–16–4 3–12–4	
Watermelon..	Acid	2–12–2	5–10–5	4–16–4	0–16–0	2–16–2	4–16–4	
Pumpkin } . Squash } ..	slightly acid	3–12–4	4–12–4	5–10–5				
Sweet Corn...	Moderately acid	2–16–2	3–12–4	4–16–4 4–12–4	0–16–0	2–12–2 0–16–0 2–16–2	3–12–4 2–12–2 2–16–2 0–16–0	

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